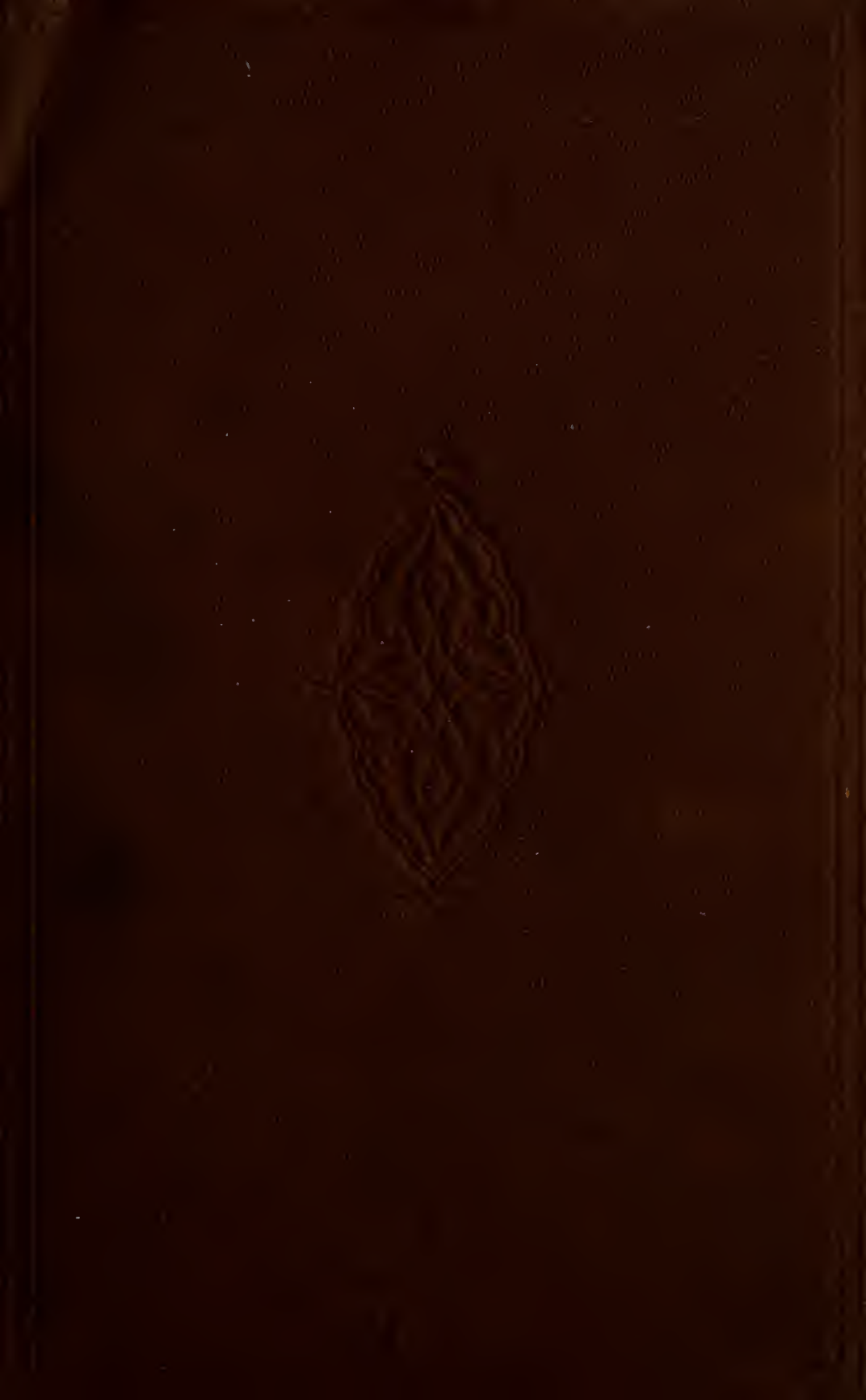

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SURGERY OF THE ARTERIES

Lettsomian Lectures

OF THE

MEDICAL SOCIETY OF LONDON

1875

BY

C. F. MAUNDER

SURGEON TO THE LONDON HOSPITAL
FORMERLY DEMONSTRATOR OF ANATOMY IN GUY'S HOSPITAL

WITH EIGHTEEN ILLUSTRATIONS

LONDON
J. & A. CHURCHILL, NEW BURLINGTON STREET
—
1875

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PREFACE.

THESE Lectures are published, with some few additions, almost verbatim.

I had intended to append Tables of Cases, which have been collected to illustrate various points discussed; but finding that their extent would entail very great expense in publishing, I confine myself to stating the sources whence they are derived.

"Medical Times" and "Lancet," from 1860 to 1874 inclusive.

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The illustrations are borrowed from my work on "Operative Surgery."

C. F. MAUNDER.

16, Queen Anne Street,
Cavendish Square, 1875.

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ERRATA.

Page 47, *for* "tenacity," read "tonicity."

Page 126, *for* "Case 23," read "Case 22."

Do. *for* "Case 8," read "Case 9."

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SURGERY OF THE ARTERIES.

LECTURE I.

ON ANEURISMS.

Mr. President and Gentlemen,—

When your Council did me the honour to nominate me as Lettsomian Lecturer, I accepted the office before deciding upon the nature of my discourse. It first occurred to me to devote each lecture to a separate and original subject, but I abandoned this idea in favour of the "Surgery of the Arteries." I proposed to make this very complete, but when I came closely to look into the matter I found that the subject was so vast, and the time allotted for the delivery of the lectures (three hours) so short, as to compel me to restrict myself, in very great measure, to my *own personal* experience in this department of surgery. I the more regretted this restriction because, as the work progressed, it became apparent that even this experience carried me over a large area, as will be understood by the fact that it had fallen to my lot to ligature an artery in its continuity, under all sorts of important

TABLE OF MR. MAUNDER'S TWENTY-SEVEN CASES OF LIGATURE OF ARTERIES FOR ANEURISMS, WOUNDS AND HÆMORRHAGES, AND TRAUMATIC INFLAMMATION.

Case.	Sex.	Age	Nature of disease or injury.	Operation.	Result.	Remarks.
1* 2	M.	37	Aortic aneurism (supposed innominate)	Ligature of common carotid and of third part of subclavian simultaneously, Sept. 18th, 1867	Died on the sixth day	Antiseptic silk ligature, long, was used; no suppuration; the aneurism was full of clot, and this was continuous with clot in the aorta towards the heart and choked the great vessel.
3	M.	46	Axillary aneurism.....	Ligature of subclavian, third part, March 18th, 1871	Died on the ninth day	Died of pericarditis and pleuritis; antiseptic catgut ligature, cut short, was used, and is still on the artery, but decomposition occurred in the wound.
4	M.	40	Inguinal aneurism.....	Ligature of common iliac, Sept. 21st, 1867	Died on the sixth day	Gangrene of the whole extremity.
5	M.	26	Carotid aneurism at bifurcation, left side	Ligature of common carotid, Sept. 22, 1868	Recovered...	Antiseptic silk ligature, cut short; healed in a few days, without suppuration; ligature still on artery.
6	M.	32	Femoro-popliteal aneurism	Ligature of superficial femoral, May 17th, 1872	Recovered...	Wound healed by primary union over antiseptic catgut, cut short. Readmitted September, 1872. Dr. Sutton suspected aneurism at the base of the heart; death; an aneurism the size of a walnut was found close to the origin of the coronary artery.
7	M.	42	Popliteal aneurism	Ligature of superficial femoral, June 16th, 1872	Recovered...	Antiseptic catgut ligature, cut short; wound quickly suppurated.
8	M.	16	Traumatic aneurism after a stab	Ligature of popliteal artery; Dec. 21st, 1862	Died	The popliteal vein was also wounded; primary amputation was performed.
9	M.	47	Extensive suppuration; hæmorrhage	Ligature of superficial femoral, March 9th, 1867	Died	Disorganized knee after injury.
10	M.	19	Punctured wound	Ligature of superfic. femoral at wound, Sept. 7th, 1867	Recovered...	*Venous* blood flowed from the distal side of the wound.
11	M.	28	Wound	Ligature of superfic. femoral at wound, March 25th, 1871	Died	Exhaustion from primary hæmorrhage.
12	F.	3½	Open knee-joint.....	Ligature of superfic. femoral, April 29th, 1869	Recovered...	Profuse suppuration quickly arrested; fishing-gut ligature, cut short; antiseptic dressings.

Case.	Sex.	Age	Nature of disease or injury.	Operation.	Result.	Remarks.
13	M.	66	Secondary hæmorrhage	Ligature of brachial artery, June 15th, 1866	Died on the fourth day.	No more bleeding; pulse at the wrist on the third day after operation.
14	M.	31	Wound of wrist; secondary hæmorrhage	Ligature of brachial artery, Nov. 16th, 1871	Recovered...	Antiseptic catgut, cut short.
15	M.	38	Wound of hand; secondary hæmorrhage	Ligature of brachial artery, March 17th, 1865	Recovered...	
16	M.	21	Traumatic aneurism of brachial artery	Double ligature at wound, April 1st, 1870	Recovered...	Pulse at wrist twenty-four hours after operation.
17	M.	28	Suppuration of hand and secondary hæmorrhage	Ligature of brachial artery, March 11th, 1873	Recovered...	Bleeding did not recur; death from pyæmia on the eleventh day; antiseptic catgut, cut short.
18	F.	47	Inflamed hand	Ligature of brachial artery, July 22nd, 1870	Recovered...	Died September 15th with symptoms of pyæmia.
19	M.	30	Wound at elbow; secondary hæmorrhage	Ligature of ulnar artery at wound, May 27th, 1872	Recovered...	
20* 21	F.	49	Suppuration and hæmorrhage from foot	Ligature of ant. and post. tibials, Nov. 16th, 1868	Died	No further hæmorrhage; exhaustion.
22	F.	66	Hospital gangrene; hæmorrhage	Ligature of anterior tibial, Sept. 4th, 1863	Recovered...	Gangrene soon ceased; gradually sank, and died many weeks after.
23	M.	30	Cancer of axilla; hæmorrhage	Ligature of axillary artery, Dec. 3rd, 1861	Died	Had lost a large quantity of blood.
24	M.	70	Lacerated axillary artery; traumatic aneurism; hæmorrhage	Ligature of axillary artery, July 7th, 1872	Died	Had lost a large quantity of blood.
25	F	50	Cancer of tongue; hæmorrhage	Ligature of lingual artery, Dec. 29th, 1869	Recovered...	Died from extension of disease March 17th, 1870.
26	M.	20	Gunshot wound; secondary hæmorrhage	Ligature of common carotid, Sept., 1855	Died	Hæmorrhage arrested; but the patient had lost a large quantity of blood.
27	M.	24	Necrosis of lower jaw; hæmorrhage	Ligature of common carotid, March 30th, 1861	Recovered...	

* Two arteries tied.

circumstances, no less than seven-and-twenty times, and this exclusive of other cases of injury and disease of the arterial system which have come under my care. After putting my material together I have had to cut it down, and cut it down, until at length I feel that I have not done justice either to my subject or to other labourers in the same field. Many points of great interest in physiology, pathology, diagnosis, prognosis, and practice have, from sheer necessity, been omitted, while others have been but glanced at.

The table, on pages 2 and 3, shows the arteries, and the causes for which they were ligatured.

Most of the drawings shown were used by Professor Holmes to illustrate his recent admirable lectures at the Royal College of Surgeons, and have been kindly lent to me by him. I may also state at once, in order to avoid repetition, that I shall frequently quote those lectures, published in the *Lancet* during 1872-73-74.

I proceed now to consider certain Aneurisms.

Pathology teaches that an aneurism depends generally for its cure upon the filling and obliteration of its cavity by fibrine deposited from the blood; and experience shows that this deposit is aided and accelerated by means which retard and diminish the quantity of this fluid circulating through the sac.* The inherent tendency of the

* J. Tuffnell, "The Successful Treatment of Internal Aneurism," 1864.

blood to deposit fibrine under favouring circumstances is also recognized.*

This preparation of innominate aneurism† is a good illustration of the value of rest and depletion. In October, 1824, the patient from whom this specimen was removed came under the care of Mr. Luke. Treatment by purgation and bleeding was adopted. Between October 20th, 1824, and June 14th, 1827, he was bled forty-two times, in quantities varying from six to sixteen ounces. The symptoms of aneurism gradually subsided, and the man died a considerable time afterwards. The aneurism will be seen filled by fibrinous coagula.

Unlike many diseases to which the expectant treatment is applicable, spontaneous or natural recovery can in no case, in the instance of aneurism, be relied on, though sometimes met with. The chief modes of spontaneous cure are three: lamination, with or without obliteration of the vessel;‡ plugging of the artery beyond the aneurism by a portion of clot; inflammation and sloughing of the sac. Of these, the first is a desirable method, and highly worthy of imitation; the second when it occurs in certain regions is fraught with danger; the third can scarcely be regarded as remedial, but,

* Case by Dr. F. H. Daly, of Dalston, in which the symptoms of a large abdominal aneurism were present, and cure resulted. "Lond. Hosp. Rep.," vol. iii. p. 179.

† Lond. Hosp. Mus., C.b. 28.

‡ Lond. Hosp. Mus., C.b. 18. Aneurism filled with laminated fibrin; artery pervious.

on the contrary, may be very destructive to life; yet the following is an example of recovery after rupture of a popliteal aneurism.

J. W——, twenty-eight years of age, bricklayer, came under my observation on February 16th, 1864. Six months previously, a rapidly grown swelling in the ham had burst, and nearly destroyed the patient by bleeding. With intervals of a few days, hæmorrhage recurred twice. When seen there was still a purulent discharge from the popliteal space, extensive cicatrization, and a leg much flexed on the thigh. No pulsation could be felt in the tibial arteries.

Taking, then, the teachings of Nature, and selecting her most beneficent means of promoting spontaneous cure as a guide, the idea, of treating aneurism by diminishing the flow of blood through it by moderate pressure on the feeding vessel, occurs.

The merit of re-introducing and carrying to a successful issue compression, *indirect*, *moderate*, and *intermitting*, is due to our Irish brethren; and from this surgeons advanced step by step to *complete* and *continuous* (instrumental and digital) compression, till by the latter method and the aid of ether, opium, or chloroform, aneurism is often cured at one sitting. The avoidance of a cutting operation (even so successful an one as that of Hunter) naturally commended compression to the notice of surgeons, and accumulated experience speaks most

strongly in its favour. This former method has for its object the gradual filling of the sac by layers of fibrine placed one upon the other, as a decorator puts on his coats of paint, with a view either to fill the cavity or to strengthen the wall of the sac so as to enable it to resist the impact of the blood tending to enlarge it. To this end the flow of a certain amount of blood through the tumour is essential, and when the cure is accomplished no more desirable result can be imagined. Occasionally the channel of the vessel remains open while the walls of the tumour are sufficiently thickened to amount practically to a cure; and thus while the disease is arrested circulation proceeds as in a state of health. This is a condition of parts much to be desired in the case of carotid aneurism, in order to avoid interference with the cerebral circulation. But the application of this intermitting method is not always successful, as in the case of R. J., to be mentioned, where it failed after a trial of three and a-half months; and often when it is successful is extended over weeks and months, as in Dr. Peatson's case, where an axillary aneurism was cured after a trial of three months. When comparatively painless, the necessary restraint is very irksome, and to persons of an irritable temperament almost intolerable; thus giving rise to much mental suffering. Physical pain of a severe character is not unfrequently attendant, and especially when compressing instruments are employed. The skin often becomes

inflamed and vesicates or sloughs, causing a new source of distress, delaying treatment and postponing the cure. It may be said, with some amount of truth, that the above are accidents which ought to be avoided—that the method is good and its application faulty; but you cannot make an irritable person patient at will, nor a tender skin tough at pleasure. By attention to details, and close watching, such as few can command, a larger percentage of recoveries would accrue. One great advantage claimed for compression is that while the treatment is being conducted the collateral circulation is being established, and thus the risk of gangrene supervening on a cure is greatly lessened. This is doubtless true in great measure, and indeed were it not so only those whose aneurisms could be removed by amputation, or got well spontaneously with an open channel, would recover from the disease. At the same time, during the progress of an aneurism and before treatment has commenced, the impediment offered to the progress of the blood to parts beyond the tumour by the aneurismal condition of the vessel, has already led to some enlargement of the anastomosing vessels, as was seen in Case 5, who, six weeks prior to ligature of his common carotid, had undergone amputation of the thigh for ruptured popliteal aneurism. An unusual number of vessels required ligature. On the other hand, this recently-acquired freedom of circulation by collaterals has a tendency to make the limb inde-

pendent for its supply of nutriment of the main vessel, and thus in rare instances the remedy if employed too long may obviate the very object we had in view, namely, to diminish the quantity of blood flowing through the sac.

Again, the capability of the blood to deposit fibrine doubtless varies in individuals, and must take its place among the possible causes of failure in conjunction with compression. In one instance of popliteal aneurism seen by me, a nerve found running upon the superficial femoral artery at the operation of ligature was presumed to have been the cause of severe pain and of inability to bear compression.

It is to be expected that a particular mode of treating a particular disease will sometimes fail, and the moderate and intermitting compression treatment of aneurism is no exception to the rule, whether instrumental or digital. The latter method should be used when circumstances will admit. Skin seems to be less irritating to skin than any other substance, and the requisite amount of pressure can be better appreciated directly by the hand than through the medium of another agent. Various instruments are employed to exercise compression on the principle of the tourniquet, both elastic and non-elastic; and also a conical ten-pound weight suspended from a cradle or held *in sitû* by the patient or an assistant. These used alternately, or shifted along the artery with short intervals of time, enable the indi-

vidual to tolerate the treatment which, if attempted always at the same spot, would soon become unbearable.

One of the most important questions to answer is: How long may compression be employed? In a general sense (and excepting popliteal aneurism) the reply is—so long as the disease shows no tendency by alteration in its physical characters to endanger the life or the limb of the sufferer—a carotid aneurism may be encroaching on the trachea; a popliteal may, by enlarging, threaten either to burst or to lead to gangrene, and then the ligature must be resorted to. But, notwithstanding the diminished risk of gangrene as a consequence of enlargement of the collaterals, the result of compression, Mr. Holmes has very properly suggested that the plan cannot be continued indefinitely without, in some instances, exhausting the strength, the patience and endurance of the patient, and it may be not without compromising either his limb or his life.

One would wish to push compression to its utmost in the case of carotid aneurism, and would resort to the ligature soonest in the instance of popliteal aneurism, because the results of ligature of these two arteries are so widely different.

In these days, when all are intolerant of slow progress, even the treatment of disease demands expedition, and certainly for aneurism it has been used in the shape of continuous compression, either instrumental or digital. The employment of an anæsthetic or of morphia during a number of consecutive hours

allows of the application of *continuous* and *complete* compression for a like period, and often with the effect of curing the disease at one sitting. At any rate, a few sittings will generally suffice for the arrest of the disease, with the saving of much pain, inconvenience, and time to the patient. The means are either instrumental or digital. In the one case either the pad of a tourniquet is firmly screwed down upon the afferent artery, or the fingers or thumbs of a relay of assistants effect a similar object. As already stated, where skilled aid can be obtained, digital compression is the more desirable, although an individual can only make efficient pressure (on the femoral, for example) for ten consecutive minutes. The patient himself will often prove to be a most useful assistant, as in a case of Mr. Bryant's, where the man cured his own popliteal aneurism by four hours of digital compression.

Notwithstanding the value of chloroform under most operative circumstances, there cannot be a doubt that its prolonged exhibition entails great risk of life, as in my case of abdominal aneurism, where distal compression was being employed, the patient dying between the third and fourth hours.

Mark T——, forty-one years of age, admitted into the London Hospital, January 23rd, 1874. The patient is a carpet weaver, is often called upon to lift heavy weights, and to make pressure upon his epigastrium during his work. About eighteen months ago, after raising a heavy beam, he felt a pain "in

the stomach." He left off work in consequence, and kept his bed. His appetite was poor, and he was sick after meals. After a time he resumed his work, but the sickness has continued, more or less, ever since. He daily experiences sudden shortness of breath. A swelling gradually arose, which was soon observed to pulsate. He has been a soldier in India and has had dysentery and ague, and probably ascites.

On examination, there is a globular tumour at the epigastrium, probably about the size of a small cocoa-nut, projecting more to the right than to the left of the middle line, and protruding the anterior abdominal wall unnaturally to the extent of an inch. It is distinctly pulsating, and expansile, and synchronous with the radial pulse. There is also a bruit to be heard. The femoral arteries pulsate with equal force. The pulse generally is compressible and weak (77). He complains of pain in both lumbar regions, and also in the right scapular region. There is no bruit over the spine.

Treatment.—To remain in bed and to take three minims of tincture of aconite every four hours under observation. Middle diet and milk, but is requested to eat and drink as little as he can do with.

On January 31st Dr. Sutton is requested to see the case.

On examining the chest, the cardiac dulness is normal. Heart sounds natural. The capacity of both sides of the chest is somewhat diminished,

probably by the upward growth of the tumour. The occasional vomiting is probably due to the proximity of the swelling to the solar plexus.

February 4th.—Pulse 68, feeble—regular. Does not appear to have been much affected by the aconite. Temperature normal. After slight exertion he feels as if all his breath has gone away. Vomits occasionally without any apparent cause. Omit the aconite.

February 9th.—Pulse 66. Much sickness yesterday.

February 21st.—The patient noticed this morning that on standing up the pulsations of the tumour became more frequent, and on an examination they proved to be 128 per minute, whilst when recumbent they were only 68.

February 28th.—The tumour is much the same, and the patient experiences less pain. Pulse 84. Repeat the aconite mixture, and add five grains of iodide of potassium to each dose.

March 5th.—No improvement in the tumour or in the general symptoms.

March 19th.—Pulse varies very much in frequency even when the patient is recumbent, and rises rapidly if he assumes the upright posture.

March 23rd.—The nature of his case and the risk to be run having been explained to the patient at the last visit, distal pressure was adopted to-day whilst he was under the influence of chloroform.

4.20 p.m.—Pulse 108. The abdominal tour-

niquet, a sponge intervening the pad and the skin, was cautiously screwed down upon the aorta, just to the left of the umbilicus, until pulsation ceased in the femoral arteries. Two house-surgeons and Mr. Harvey, the dresser, watched the patient. Mr. Maunder remained with him also during the first three-quarters of an hour.

4.23.—Pulse 56. Is taking chloroform well.

4.30.—Pulse 68.

4.43.—Pulse 72.

5.—Pulse 68.

5.19.—Pulse 62.

5.34.—Pulse 100.

5.50.—Pulse 88.

6.40.—Pulse 120.

7.40.—Pulse stopped. Death.

Extract from Pathological Records, London Hospital:—

AUTOPSY.

"Mark T., æt. forty-one. Admitted January 23rd, 1874, died March 23rd, 1874.

"*Body*, well developed, wasted, but not greatly so.

"*Heart*, normal, left ventricle flaccid.

"*Lungs*, normal, congested.

"*Abdominal cavity*, peritoneum normal, containing a little dark-stained serum—no blood clot. No aneurism was seen until viscera were removed. On looking at under surface of left lobe of liver, a tube-like body was seen projecting, and it felt like a

greatly dilated vessel; this proved to be a portion of the aneurismal sac. On removing intestines and stomach (which proved to be healthy), and tracing up the aorta, immediately under liver, and involving its left lobe, was a large aneurismal sac. This lobe was much thinned, in fact, only about half an inch in thickness, in consequence of the aneurism having grown into it. This sac pressed back, and had excavated the spine; in fact, one vertebra was almost eroded through. This sac contained a decolourized clot in its posterior part. Thoracic aorta healthy.

"*Kidneys*, healthy.

"*Spleen*, large; congested looking."

True it is, that the grand result anticipated by the use of chloroform in conjunction with compression, if the latter succeed in bringing about coagulation, as in Mr. Holt's case,* after fifty-two hours, cannot be overestimated, still I advocate a more thorough trial of morphia either exhibited by the mouth or subcutaneously. In one of my cases the chapter of events, where morphia was employed, is encouraging for the future. The patient dozed, took his meals, and smoked his pipe, and submitted to continuous digital compression for twenty-three hours with scarcely a complaint; and at the expiration of this time expressed himself as capable of enduring treatment many hours longer. Digital has many advantages over instrumental compression—it can be employed with more precision and discrimination.

* "Clin. Soc. Trans.," vol. vii. p. 56.

Thus, when a very small portion of artery only is accessible to pressure; at the root of the neck for example, or on the common femoral, and, probably, it is in the case of this latter, to which continuous compression is often applied, that the most striking results of this method will be witnessed.

It is difficult, when using a weight and tourniquet alternately, as is often the custom when intermitting or gradual compression is employed, to restrict the pressure to the *common* femoral, and consequently a too free supply of blood goes to the sac through the anastomosis thus established. Again, with the utmost care it is quite impossible to apply even digital compression by relays of assistants, so as to prevent a trickling of blood now and then along the afferent artery. This is likely to happen when the assistants are changed. To obviate the necessity of change every ten minutes, a weight (ten or twelve pounds) has been used, resting on the back of the finger of the assistant, and thus enabling him to continue his efforts for a longer period. Mr. T. Shapley, H.S. of the London Hospital, tells me that by the aid of the weight suspended, and resting by one end upon the fingers, the assistants can maintain efficient pressure, during thirty minutes, on the femoral artery.

Compression failing we may often resort to Ligature.

The operations having for their object the application of a single ligature to an artery for the cure of aneurism are two—proximal and distal. The former

is always preferred, the latter is a matter of necessity. The distal operation, suggested by Brasdor, first performed by Deschamps for aneurism of the femoral artery, is now restricted to aneurism at the root of the neck, and is especially adapted to aneurism of the root of the carotid, because a ligature can, under these last circumstances, be placed upon the carotid artery beyond the sac—*no branch intervening.*

The application of this method to this vessel, first practised with success by Wardrop, is at once acceptable to our minds, on the principle that a structure no longer essential to the economy may be expected to dwindle and degenerate into a more simple form of living tissue. Thus, the portion of the artery situated between the ligature and the sac being no longer required to transmit blood to distant parts, becomes, as it were, a part of the aneurism, and with this latter the seat of coagulum, and ultimately impervious.

This did not occur in Mr. Holmes' case of double ligature. The carotid remained pervious. It is, however, illustrated in another drawing, in which the clot in an innominate aneurism is continuous with clot in the carotid artery, the subclavian being pervious.

Again, the structures beyond the ligature, which have been hitherto accustomed to receive their due supply of blood through the carotid artery, doubtless have as great a necessity for blood now as previously. This reaches them both through vessels well-known and named by the anatomist

which enlarge quickly, and also through channels hitherto so small as to have escaped notice, but which now dilate. The effect of this dilatation of collaterals is twofold. First, to maintain vitality and health; and, secondly, to divert the current of blood from the aneurismal sac and carotid artery, substituting themselves for this latter.

The development of a collateral circulation where a main artery has been obstructed is one of the most beautiful provisions of Nature. Without this our efforts both to cure aneurism by consolidation of the contents of the sac, and to arrest hæmorrhage by ligature, would be fruitless. Many injuries and diseases which are now so successfully dealt with by Art would be quickly fatal, were it not possible to obstruct an arterial trunk with impunity. Even the spontaneous cure of aneurism and the natural arrest of hæmorrhage, should these necessitate occlusion of the channel of the vessel, would necessarily lead to gangrene without its interposition.

The collateral circulation is established by the dilatation or enlargement of arteries, arterioles, and capillaries, which can by any possibility aid in furthering the supply of blood to the part requiring it. Of the agents that favour this, the propelling power of the heart is probably of the first importance; but the fact that very little force is required to prevent blood flowing from the open mouth of an artery during a primary amputation (for example, with the patient in full vigour), suggests that some other power besides the muscular action of this organ

must aid in carrying it to the extremity of a limb, when the person is enfeebled by copious hæmorrhage.

Several theories have been advanced to explain it.

One is, that it consists of dilatation of vascular communications already existing. We are all familiar with the fact that blood-vessels are supplied with nerve fibrils from the sympathetic—the vaso-motor nerves. It is not so generally known, however, that on the coats of blood-vessels there are also nerve fibrils derived from the cerebro-spinal system which have been denominated "trophic" or "vaso-inhibitory nerves."* Broadly stated, it would appear that the sympathetic nerves produce contraction, while the cerebro-spinal nerve fibrils counteract this action, and produce dilatation. In the blood-vessels of limbs it is probable that nerve fibrils pass from the nerve trunks to the arterial coats. I have had myself to remove a forefinger for ulceration subsequent to injury of the median nerve above the wrist; and similar cases have been recorded. In such an injury, then, these fibrils will no longer hold in check the action of the vaso-motor nerve; and consequently we have contraction of the vessels, loss of temperature, and molecular death. On the other hand, the well-known experiment of Claude Bernard —of section of the trunk of the sympathetic in the neck with consequent dilatation of the vessels, and rise of temperature of the head and face of that side—

* "Rutherford's Lectures," *Lancet*, 1872; and Schiff, quoted by Wunderlich, translated by W. B. Woodman. 1871.

points out another fact, that when the trunk of the sympathetic is severed we get dilatation of blood-vessels beyond the point of section. In ligature of the blood-vessel of a limb I perform an experiment strictly analogous to that of Bernard. I compress and cut across the vaso-motor supply. The consequence of this is that the cerebro-spinal nerve fibrils of the distal arteries are no longer opposed by the vaso-motor nerves, and so the blood-vessels dilate. This enables us to understand, to some extent at least, the establishment of collateral circulation by the dilatation of pre-existing inosculations.

Another theory is that of Putzy and Tarchanoff,* who are of opinion that there is no necessity for supposing the existence of actively dilating nerve fibres. Their experiments were as follows:—1st, on division of one sciatic nerve in a dog, and then cutting off a toe from each hind foot, a stream of blood from the paralyzed side was considerable, and that on the non-paralyzed side insignificant. The excitement—mechanical, chemical, or electrical—of the distal end of the cut nerve reversed the phenomena, the bleeding on the paralyzed side almost ceasing. As this might be explained by general stimulation of the lower extremity, similar experiments were performed on a curarized frog, with exactly the same results, and with the further advantage that the dilatation and contraction of the vessels could be seen with the microscope. Over-stimulation of the nerve reversed

* "Centralblatt," August, 1874.

the phenomena again, and application of the stimulus a little lower down the nerve produced contraction again. With the dilatation of the blood-vessels there is elevation of temperature; and, after excitement of the nerve, lowering of the temperature accompanied the contraction of the vessels. After the lapse of some days the vessels had regained their normal size. They thus assume that the regulation of the blood circulation in a part is under the direct control of *local* nerve centres.

Hermann * states that Bernard's and Schiff's theories about dilating nerves are not proved, and that their mode of action is not intelligible.

The fact that the great majority of the arterioles resume their normal size after a time in a limb, the main artery of which has been obstructed, favours the hypothesis of the existence of *local* nerve centres. Another aid to collateral circulation is probably to be found in the temporary emptiness of the vessels beyond the ligature. The ligature necessarily obliges the blood usually brought to the obstructed vessel to find another outlet, and it does so naturally in the direction of the least resistance —namely, the emptied vessels. The blood in the veins, too, deprived in great measure of the propelling power of the heart, tends to regurgitation; and thus, where the collateral circulation is chiefly conducted by the arterioles and capillaries, venous blood may be expected to flow from the distal side of a

* "Outlines of Physiology," 1874.

ligature—of the femoral, for example—as in Case 10 (p. 2). A young man accidentally wounded his superficial femoral artery with a pen-knife. Within half an hour I was called; and as he lay in the banking-house, and I proceeded to place a double ligature on the wound in the vessel, *venous* blood flowed freely from the distal side of this.

That a part shall not lose its vitality, it is probably essential that this compensating circulation be quickly established. On October 16th, 1872, my colleague, Mr. J. McCarthy, ligatured the right common carotid and the third part of the right subclavian arteries for aneurism at the root of the neck. During the operation, sphygmographic tracings of the left radial pulse were taken by Mr. W. Lang (my now excellent house-surgeon). As each artery was ligatured tension increased in the left radial, so that the pressure had to be altered. Ophthalmoscopic observations were made daily. Twenty-four hours after the operation the right disc was much paler than the left, the veins being distended and varicose. Seventy-two hours after the operation the arteries of the right disc were distinctly visible, and the veins much less varicose.

Thermometric observations were taken in both palms. The difference, at first three degrees, gradually diminished, and on the eighth day the temperature in both hands was equal. The man died on the fifteenth day of hæmorrhage from the proximal side of the subclavian ligature.

I ligatured the femoral artery of a young man

(Case 11) for wound an hour or two after it had been received. He had lost a very great deal of blood. No complaint was ever made about the state of the limb, neither were there any indications that its circulation had been interfered with. Still a gangrenous state of the wound supervened, and the patient died typhoid from loss of blood.

I chanced to be present when a friend accidentally wounded the femoral artery, in opening a psoas abscess in a child. The vessel was at once secured by a double ligature, and the case recovered as though nothing unusual had transpired.

Without this dilatation the *vis à tergo* might be expected to force the blood current against the sac and the ligature, in order to overcome the resistance offered by the latter, and so tend to a more rapid growth of the tumour. I must, however, add that the late Mr. Guthrie did not accept the above as the explanation of the curative power of the distal operation, but rather ascribed it to an inflammation, which spreading from the ligature involved both the artery and sac, and ultimately led to obliteration. But, inasmuch as inflammation of sac, suppuration and sloughing, occasionally follow other methods of treating aneurism, and indeed no treatment at all, and since there are numerous examples of the distal operation on record where no such mishap occurred, it will be scarcely just, with our present knowledge, to regard diffuse inflammation as a necessary sequence to it.

As a warm advocate of the distal operation for carotid aneurism, Mr. Wardrop proposed to extend it to aneurism of the innominate artery. He argued that since pulsation often persisted, for a shorter or longer time, in an aneurism which had been subjected to the Hunterian operation (ligature of the artery on the cardiac side of, and at a *distance* from, the seat of disease), it was, therefore, not essential to success that circulation through the sac should cease absolutely. He divided the mass of the blood passing through the innominate artery by three; giving one-third to the carotid, another to the subclavian beyond the scaleni, and the last to its branches; and suggested that an obstruction of the carotid and of the subclavian in its third part would necessarily cut off two-thirds of the blood formerly traversing the innominate. By thus diminishing the supply of blood he thought to lead to coagulation in the sac. Possibly if his reasoning were correct the result would be as he hoped; but unfortunately he forgets, what he laid so much stress and importance upon when discussing this operation in connection with carotid aneurism—the immediate and rapid enlargement of those vessels upon which the circulation must in future depend. Doubtless the left subclavian and the left carotid will share with the branches of the ligatured subclavian the necessary distribution of blood, but not to the extent of restricting to the latter vessels the quantity which they originally transmitted; they

also will enlarge; and, as Mr. Holmes has pointed out, a channel through the aneurism (as in Mr. Fearn's case) is often maintained, while a practical cure in the shape of a deposit of fibrine on the walls of the tumour takes place. He has also stated that the obliteration of one or the other of the two main branches coming off from an innominate aneurism is a very common post-mortem phenomena, and says, "I think there are sufficient specimens at hand to show that it is usually accompanied by obliteration of the portion of the tumour which is in connection with the obliterated vessel." This latter remark is equally applicable to aortic aneurism.* (A drawing exhibited represented a case of fusiform aneurism of the aorta. It is practically cured though pervious, and the origin of the left subclavian is obstructed.)

In a given case of aneurism at the root of the neck the surgeon will not omit to endeavour to determine whether or not one or other artery is or does become obstructed spontaneously, as such would be a first and grand step towards a cure of the disease, and the operative indications would be clear, as in Dr. Herbert Davies' case of innominate and subclavian aneurism.† Dr. Davies writes, "In the above case Nature had done half of the distal operation, and by far the more difficult half, and as the dissection proves, to our chagrin, nothing would

* Dr. Cockle, "Med. Soc. Proceeds.," vol. i. p. 5.

† "Lond. Hosp. Rep.," 1864, vol. i. p. 1.

have been easier than to have put the remaining fluid contents of the sac in a state of complete stagnation. The subclavian and its branches were already occluded, and a ligature upon the still pervious common carotid was alone requisite."

Again, in contemplating ligature of one or more vessels for aneurism at the root of the neck, temporary compression should be tried on both, in order to ascertain by which, thus obstructed, the aneurism is chiefly, if at all, affected. If distal pressure on a particular vessel cause a decided effect, that artery alone should be tied, and the result watched. From the carotid the distal operation was tried for innominate aneurism, and accident showed that it might even be beneficial in aortic aneurisms, or when the aorta formed part only of the sac.* As an example, I record my own

Case 1, 2. *Aortic Aneurism, suspected Innominate.*—John M——, æt. thirty-seven, a commercial traveller, was admitted into the London Hospital, on July 9th, 1867, under the care of Dr. Davies; and afterwards was transferred to the care of Dr. Sutton and the author. Seven years ago he had been treated and cured of a popliteal aneurism by compression. Twelve months ago he began to suffer pains in the right shoulder, head, and neck, which became worse. Fourteen days before admission he felt a pulsation over the present site of the

* Heath, "On Treatment of Intrathoracic Aneurism by Distal Ligature."

tumour—the position of the innominate artery. The treatment consisted in, absolute rest in bed; lead and opium; digitalis and the bromide and iodide of potassium were administered. Ice externally. The disease steadily and rapidly progressed, accompanied by a hard ringing cough and excruciating pain in the shoulder, and the double distal operation was determined upon.

Operation. Sept. 18*th*, 1867.—To-day one ligature was placed on the right common carotid artery, and another on the third part of the right subclavian. Choloroform having been administered in an adjoining room, the patient was placed upon the operating table on his back, the face being turned towards the left, so as to put the sterno-mastoid muscle on the stretch, and the arm pulled down and held in position in order to lower the shoulder. The integuments of the neck were drawn slightly down over the clavicle, and an incision was made through them along the middle of that bone. Several small veins now bled freely and were at once ligatured. Traction being removed, the natural elasticity of the skin (much impaired) caused the wound to correspond to the region of the neck just above the clavicle. The deeper structures rendered œdematous, or rather, brawny, and glued together by albuminous effusion, were cautiously divided, and at length, and at a great depth from the surface, the external jugular vein, now swollen to the size of the forefinger, was exposed.

During this part of the proceeding one or two small veins and a small artery required ligatures. The external jugular vein, passing in a direction from above downwards, forwards, and inwards, was not meddled with; but the layer of deep cervical fascia which this vein penetrates was divided, and then the operator, with two pairs of forceps tunnelled, as it were, towards the expected seat of the subclavian artery, removing a quantity of fat and a lymphatic gland usually found here. Just prior to the last step a short longitudinal incision was made to join the inner extremity of the first to give more space. The finger introduced into the wound made out with tolerable facility the cords of the brachial plexus in their sheath, and a little further search discovered the artery pulsating feebly. Neither the tubercle of the first rib, nor the round tendon of the scalenus anticus muscle could be clearly defined by the finger by reason of the indurated condition of parts.

The wound was now carefully dried with sponge, and at the bottom of it a small vein could be seen lying, as the operator suspected, upon the artery, and around this latter a ligature was readily carried upon a twisted aneurism needle. The artery thus picked clean off the first rib was seen and recognized by many bystanders, while pressure upon it stopped pulsation at the wrist.

The ligature of the subclavian effected, the operator proceeded to expose the common carotid

artery high up on account of the high position of the aneurismal tumour. A short longitudinal incision was made opposite the thyroid-cartilage and parallel to the inner border of the sterno-mastoid muscle. The superficial structures and deep fascia having been divided, the internal jugular vein, enormously distended, bulged into view, while smaller veins communicating with this traversed, at short intervals, the line of incision. Before the wound in the infiltrated and congested tissues could be deepened it was necessary to place a double ligature upon two of these vessels, and sever them between them. The finger could now be passed deeply into the wound, and the artery was recognized by the sense of touch, although the patient being very low pulsation could with difficulty be detected. Some brandy and water was at once injected per rectum, and the man rallied. The artery laid at a great depth from the surface, but the edges of the wound having been separated by retractors, the sheath was laid bare and opened, and a ligature passed around the vessel from without inwards. Both wounds were now sponged out with carbolic acid and oil, and their edges having been approximated with interrupted sutures, and again dressed with lint soaked in carbolic acid and oil, the patient was returned to bed. Very little blood was lost during the application of either ligature.

Remarks upon the Operation.—When the patient

was put upon the table his neck had a very uninviting appearance for a surgeon contemplating ligature of the subclavian artery. The operation is sufficiently difficult on the dead subject, but its performance there gives no idea of it when undertaken in the living subject, who is naturally stout, and whose neck is œdematous, and tissues are indurated and matted together by effusion, and the veins enormously distended.

From the commencement to the termination of the operation, neither the boundaries of the region, nor the guides to the position of the artery, were scarcely seen or felt. Neither the omo-hyoid muscle nor brachial plexus was seen, though the latter was appreciated by the finger. Neither the tendon of the scalenus anticus muscle nor the tubercle on the first rib was recognized satisfactorily by the finger; but the direct guide to the artery was, independently of pulsation, a small vein observed at the bottom o the wound, similar to an anatomical observation which the author had previously made when operating upon the dead subject. This procedure occupied twenty minutes.

On recovering consciousness after chloroform, the patient had lost the old pain in his shoulder, had no cerebral or other disturbance, was cheerful, and expressed himself as comfortable; but in the evening the impulse in the tumour was more marked than before operation. On the next day he said "He felt a thud at the tumour, jerking his whole

frame now and then, but this passed off as if the blood got vent." Venesection was employed.

20*th*.—The impulse is more direct, less expansive than before.

22*nd*.—Great pulsation is observed in the tumour, and at 1 p.m. he is very restless, unconscious, with a dusky face, purple lips, and cold, clammy, relaxed skin. At 6 p.m. he has rallied again. Quite conscious now, but ignorant of what has lately transpired.

23*rd*, 1 p.m.—He is again unconscious. Died this afternoon.

We have now to ask—What was the effect of applying the ligature to the carotid and subclavian arteries? It was observed by Dr. Sutton and myself that the pulsation continued forcibly in the sac a day or two following the operation. This was particularly noticed, and caused not a little anxiety lest coagulation should not occur. Subsequently the pulsation became less heaving, and, as it were, confused, undulatory, and *less* expansile; but I am unable to say that it ever wholly ceased.

Post-mortem.—The post-mortem examination was a most unsatisfactory one, as we were only permitted to examine the lower part of the neck and upper part of the chest, through the operation wounds. These latter were healthy and quite devoid of pus. The aneurism was seen lying in the position of the innominate artery, and to arise from the aorta a little to the left of the orifice of the above vessel. It had extended upwards and to the right, and in

this way covered, and was firmly adherent to, the wall of the innominate.

The sac contained very little laminated fibrine. It was almost completely filled with clot, chiefly black, but a portion of this had a pale red, partly decolourized, appearance. This black clot in the aneurism was continuous with a similar clot which extended down and completely filled the ascending portion of the aorta. The heart was seemingly free from disease, and the left ventricle was contracted and consequently empty.

The presence of so little laminated fibrine clearly showed that the conditions within the aneurism antecedent to the operation were not favourable to coagulation. It is open to suggestion that the black clot which mostly filled the sac had formed either just before death, or during dying, or even after death; but it is instructive to notice that this clot, as already said, was directly continuous with a similar clot which completely filled the ascending aorta. Now, whilst it is common enough to find a small clot in this portion of the aorta, it is rare to find it thus entirely filled with coagulum. What, then, caused the blood to accumulate in this part in this exceptional way? It was not the absence of tone in the left ventricle, for its muscle was found contracted and its cavity closed; clearly showing that it had, even to the last, sufficient power to empty itself. We are, therefore, led to look for something impeding the flow of blood from the

ascending aorta. There was nothing in the aorta itself to cause this undue accumulation, and the clot filling this vessel extended up to, and was continuous with, the clot in the aneurism. It seemed, therefore, that there was some condition within the aneurism which impeded the passage of blood from the aorta. Keeping in mind also that a portion of the clot in the aneurism directly joined to the much larger black coagulum was partly decolourized, the inference is that coagulation occurred a short time before death, and subsequent to the operation; and also, that from this paler and antecedent clot the black and recent coagulum had taken origin and extended itself. We could not argue that this paler appearance of a portion of the clot was simply due to the red corpuscles separating by gravitation after death, for it was not simply on the anterior surface of the clot; and evidence of such gravitation was entirely absent from the large black clot, both of the aneurism and of the aorta.

September, 1874.—The specimen has been very carefully dissected by Mr. McCarthy, and shows through a small aperture made in the posterior wall of the sac, the independent origin of the innominate artery. Unfortunately the greater part of the coagulum above mentioned has been allowed to fall out. A ligature is seen on the common carotid artery, just below its bifurcation. On the cardiac side of the ligature the artery

contains coagulum, but there is none on the distal side. A ligature is also seen upon the third part of the subclavian artery, with coagulum on either side of it. The branches of the subclavian, and the portion of artery between these and the sac are empty.

In the "Transactions of the Pathological Society of London," vol. xix. p. 93, the aneurism is said to involve "the arch of the aorta and the root of the innominate slightly." It is purely aortic.

Preparations * C.b. 1, C.b. 22, show how an aortic aneurism may take the place of an innominate artery.

The morbid appearances, as far as they go, tend to teach that the operation promoted coagulation within the sac.

Another circumstance in support of the hypothesis, that coagulation was induced by the operation, is the history of the patient subsequent to it. This coincides very closely with the history of cases of spontaneous cure of aneurism at the root of the neck.

My patient appeared to be dying, being unconscious, restless, and livid, and then rallied completely, but died next day. Wardrop † records similar symptoms occurring to a patient who recovered; and Dr. J. W. Ogle has had a like experience. ‡

* Lond. Hosp. Mus. † "On Aneurism," p. 98.

‡ "Path. Soc. Trans.," vol. ix. p. 167.

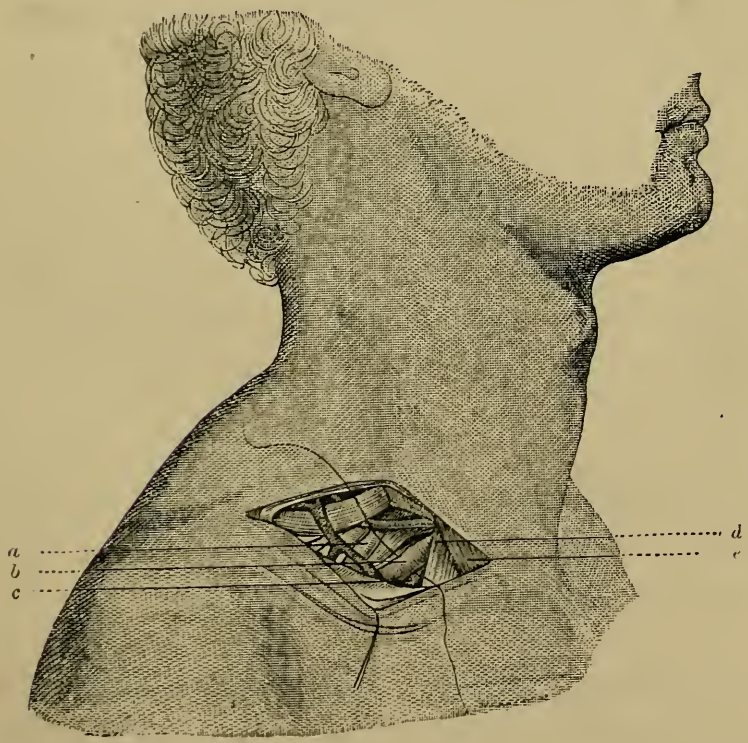
Judging from this case, and the records of others, I deem the distal operation to be worthy of repetition.

Under ordinary circumstances the outer third of the subclavian artery may be thus reached :—

LIGATURE OF THE SUBCLAVIAN ARTERY.

THIRD PART.—*Anatomical Relations.*—Here (Fig. 1) the vessel (*b*) lies in the posterior-inferior triangle

FIG. 1.



of the neck, a space bounded internally by the sterno-mastoid muscle (*e*), above by the posterior

belly of the omo-hyoid muscle, and below by the middle third of the clavicle. The vessel is covered in by skin, superficial fascia, platysma and layers of cervical fascia; running parallel with, and behind the clavicle, are the suprascapular artery and vein; crossing the vessel from above downwards, and perforating the cervical fascia to join the subclavian vein, is the external jugular vein. Above, external to, and behind the artery are the nerves of the brachial plexus (*a*), below the artery rests on the first rib (*c*); and in front and below it is the subclavian vein; in front and internal to the artery, is the scalenus anticus muscle (*d*), attached to the tubercle on the first rib, and separating the subclavian artery from the subclavian vein.

In some muscular subjects the trapezius and sterno-mastoid muscles take origin each from half the clavicle. In these instances the subclavian artery would here be covered by an additional muscular layer.

OPERATION.

To expose this vessel, the patient having the head thrown back and face turned to the opposite side, and the shoulder depressed so as to lower the clavicle, and render the artery as superficial as possible, make a mark with ink or iodine over the artery, and then draw the integument down from the neck upon the clavicle, and divide it upon the middle of the bone to the extent of three inches; in this way the

skin, superficial fascia and platysma are divided without the risk of wounding the external jugular vein. On removing the impediment, the elasticity of the skin will carry the wound upwards, and allow it to correspond to the position of the artery above the clavicle, as in the figure. If it be necessary, divide either the sterno-mastoid or the trapezius muscle, or both, to the required extent on a director. Divide also the layers of cervical fascia *without* a director, and gently hold aside the external jugular vein, or having placed two ligatures upon it, divide the vein between them. Remove or hold aside lymphatic glands. Tie also any small artery which interferes with the operation, and avoid touching the veins lest they bleed. Towards the inner angle of the wound feel with the point of the index finger for the round scalenus anticus muscle, and trace it down to its attachment to the tubercle on the first rib. Upon the rib external to the tubercle the artery will be found, sometimes with a small vein running upon it. Open the sheath, and pass the needle from before backwards, taking care not to include a nerve of the brachial plexus, or even to pass a ligature around a nerve only.

I have repeatedly seen the ligature passed around the seventh cervical nerve.

If the above incision be insufficient, a second vertical cut may be made, falling at right angles either to the centre or to the inner extremity of the first.

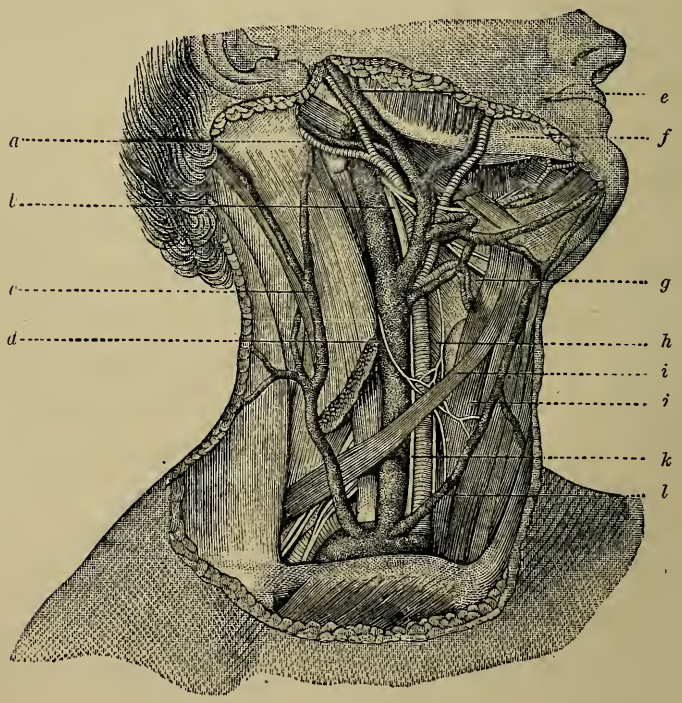
A like state of the anterior triangle of the neck

rendered ligature of the common carotid more tedious than usual. The method of the operation is subjoined:—

LIGATURE OF COMMON CAROTID ARTERY.

Anatomical Relations in the Neck.—(Fig. 2.) This vessel extends in a direction upwards and outwards,

Fig. 2.



from the bifurcation of the arteria innominata, opposite the sterno-clavicular joint, to the upper border of the thyroid cartilage, where it divides into internal and external carotid arteries. It lies in a groove

between the sterno-mastoid muscle on the outside, and the trachea and larynx on the inside, and may be here compressed against the roots of the cervical transverse processes by pressure directed backwards.

In front, the artery is crossed about its middle, and opposite to the cricoid cartilage, by the anterior belly (*i*) of the omo-hyoid muscle. Above this muscle the vessel is comparatively superficial, being covered by skin, superficial fascia, platysma, deep cervical fascia, and somewhat overlapped by the anterior border of the sterno-mastoid muscle. Parallel to, and either without or within the sheath, is the descendens noni nerve (*h*); crossing it from within outwards, the superior thyroid vein (*g*). Below the omo-hyoid muscle the artery is deeply placed, being covered in by skin, superficial fascia, more or less platysma, layers of deep fascia, sternal head of sterno-mastoid muscle, sterno-hyoid and thyroid muscles, and is crossed from within outwards by the anterior jugular (*l*) and middle thyroid veins. The internal jugular vein partially conceals the artery in front, excepting at the root of the neck, where is an interval in which is lodged the pneumogastric nerve (*k*). The lateral lobe of the thyroid body has an anterior relation to this vessel. The artery is attended in its sheath by the internal jugular vein to its right side, and the pneumogastric nerve behind and between the two blood-vessels. Behind the sheath, the artery rests on the recurrent laryngeal nerve, inferior thyroid artery, sympathetic

nerve, longus colli and rectus anticus major muscles; internally it is bounded by the trachea and larynx; and on the outside by the internal jugular vein and pneumogastric nerve.

The above description is applicable equally to the left common carotid in the neck, with this exception, that the internal jugular vein almost conceals the artery at the root of the neck.

OPERATION.

The common carotid artery may be ligatured at any point of its course, and with facility at the point of selection above the omo-hyoid muscle. An imaginary line on the surface, drawn from the sterno-clavicular joint to a mid-point between the mastoid process and the angle of the lower jaw, will sufficiently indicate the course of the artery. The head being thrown back, and the face turned to the opposite side, the surgeon ascertains the relation of the anterior border of the sterno-mastoid muscle to the artery, and will observe that the artery above the cricoid cartilage can be readily felt lying along the border of this muscle, and slightly overlapped by it.

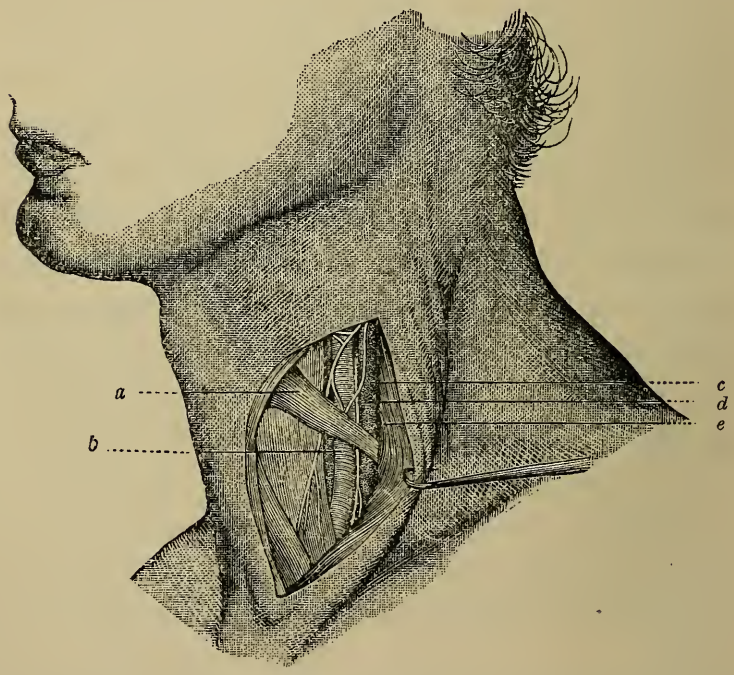
To expose the artery, an incision begun opposite to the cricoid cartilage, and carried upwards to the extent of about two and a-half inches, or begun opposite the greater cornu of the hyoid bone, and carried downwards to a similar extent along the

inner border of the sterno-mastoid muscle, should divide in order, skin, superficial fascia, platysma, and deep fascia, and expose the fibres of the sterno-mastoid muscle. The edges of the wound being now held apart, and the superior thyroid vein and descendens noni nerve avoided, the sheath of the vessel should be opened so as to admit the aneurism needle to be passed from without inwards. The coats of the internal jugular vein are so thin, and the vessel is often so close to the artery, that unless great caution be used, the vein will either be mistaken for fascia and opened with the knife, or perforated by the aneurism needle. Should the vein be injured, the wound only, and not the whole calibre of the vein, may be closed by a fine ligature. To facilitate the passage of the aneurism needle, the vein may be compressed by the finger introduced at the upper angle of the wound. The pneumogastric nerve must be carefully avoided by the needle. As a guide to the artery, the course of the fibres of the various muscles exposed should be studied; those of the sterno-mastoid running from above, downwards and forwards; those of the sterno-hyoid and thyroid downwards and outwards.

To tie the common carotid below the omo-hyoid muscle, an incision, three inches in length, beginning at the sternum and carried upwards, should be made, also along the inner border of the sterno-mastoid muscle; but the operator must recollect

that since the sterno-mastoid muscle crosses the artery obliquely in passing from the mastoid process to the sternum, the incision made as directed is not immediately over the artery, but internal to it. The skin, superficial fascia, platysma, and deep fascia being divided, the head should be carried slightly forward, whilst the sterno-mastoid muscle is pulled on one side, and the sterno-hyoid and

Fig. 3.



thyroid muscles either similarly treated on the other side, or severed. In opening the sheath and passing the ligature on the left side of the neck, the anterior relation of the internal jugular vein to the artery must not be forgotten.

The situation best adapted to expose the root of the common carotid artery on the right side is that recommended for the ligature of the brachio-cephalic trunk, viz., the interval between the sternal and clavicular origins of the sterno-mastoid muscle.

Fig. 3 shows one incision, made sufficiently long at the inner margin of the sterno-mastoid muscle to expose the common carotid artery both above and below the omo-hyoid muscle; *a* is the anterior belly of the omo-hyoid muscle, *b* the common carotid artery, *c* the internal jugular vein, *d* the pneumogastric nerve, *e* the sterno-mastoid muscle pulled aside.

CAROTID ANEURISM.

I come next to carotid aneurism, of which I have had two examples, but one patient, whom you will see after the lecture.

Case 5.—J. R——, twenty-six years old, was submitted to amputation of the thigh by Mr. John Adams, about the middle of August, 1868, for ruptured popliteal aneurism. At this time an aneurismal dilatation at the bifurcation of both common carotid arteries was also observed. He was likewise the subject of a syphilitic squamous rash. These aneurisms quickly enlarged, especially the left; and on September 22nd, in the absence from town of

Mr. Adams, and by his desire, I saw the patient with Dr. Sinclair, of Peckham.

With the assistance of Mr. James Adams and Dr. Sinclair, I tied the left carotid artery with an antiseptic silk ligature, cut short, and the wound quickly healed over it. Within a month of the operation the patient had gone to the seaside. There is still slight stationary aneurismal dilatation at the bifurcation of the right common carotid.

The disease is a formidable one at all times by reason of the important duties which the vessel has to perform, it being the chief channel of supply to the brain. My patient was the subject of aneurism at the bifurcation of *both* common carotid arteries.

It appears that ligature of the common carotid artery for aneurism is a very fatal operation, probably less than half having been successful. The operation, too, being often after the method of Anel (the ligature being applied near to or close to the sac) suppuration of this latter is of frequent occurrence. To avoid this complication, Mr. Holmes says, M. Lefort proposes to treat the case on the old plan—to tie the artery on the proximal side, then lay open the sac, turn out its contents, and tie the vessel on the distal side also. I cannot agree with Professor Holmes that there is no additional danger in so doing. I should deem the risk to be more than doubled by the second ligature, fearing hæmorrhage more from the distal than from the proximal, because the latter would be protected on

its further side by clot in the aneurism. Then again, why anticipate a large open wound, necessary suppuration, and other possible accidents? Time enough to open the sac when either dangerous swelling threatens or suppuration is established; although doubtless to place a ligature on the artery under such circumstances, supposing bleeding to occur, would be very difficult. In the case in question I was able to place the ligature low in the neck, at a distance from the sac; but in another case which I witnessed, that of Mr. Couper, the ligature was placed close to the sac, which was both unavoidably seen and touched by the operator; still the wound healed by primary union. Notwithstanding the favourable issue of these two cases, the evidence which Professor Holmes brings forward in favour of compression is very strong. Of seven cases five were cured, and in the two on which compression failed the ligature also failed. These instances, however, are but few, and with the possibility of embolism of the arteries of the brain becoming now and then associated with this method of treatment, a hasty opinion must not be formed. It certainly must be tried in suitable cases until experience tells against it. The development of the collateral circulation outside the skull during the trial is a strong point in its favour also. One other point strikes me. Should compression be *complete*, so as to *obstruct altogether* the ingress of blood from the proximal side during a period of many hours, or

should it be exercised moderately, with a view to *diminish only* the supply of blood to the sac? I incline to the latter method as being less likely to encourage embolism. By complete obstruction to the flow of blood a soft clot is likely to form, and portions of this, when the pressure is removed, may be swept on into the vessels beyond the aneurism. By the incomplete method, lamination may be reckoned upon instead of soft clot; and also, perhaps, the strongest point in its favour is, that the disease may be stayed, and yet the channel of the vessel being not altogether obliterated, the cerebral circulation is not compromised. With regard to the distal operation, I have already alluded to it as specially suitable to aneurism at the root of the carotid; and instances on record show that the operation on the left carotid will relieve urgent symptoms in cases of aortic aneurism.*

The fact that this gentleman was the subject of syphilis in its early stage, is an interesting one in connection with aneurism. Probably in a very large majority of cases of aneurism there would be no reason to ascribe the cause to syphilis. But the occurrence of three aneurisms in so young a man, the fact, too, that the carotid aneurisms grew rapidly while the patient was at rest in bed in order to allow his stump, after amputation of the thigh, to heal; and also the rather unusual rapid progress of his popliteal aneurism, would lead many

* C. Heath, "Clin. Soc. Trans.," vol. v. p. 183.

to accept a specific taint as possible cause. Syphilis having produced a cachexia, may give rise to a local manifestation in tissues predisposed to its baneful influence. As a consequence, we have two aneurisms requiring operative interference, while a third exists. Curiously enough this third, instead of increasing rapidly, recedes. How is this? True it is, that the specific poison is injurious; but happily the lapse of time is beneficial, even curative, and the softened vessel may have in this way recovered its tenacity.

There is one question of importance in reference to the amputation. With incipient aneurism present elsewhere, would it be desirable to use the elastic bandage on the condemned limb? I think not, lest the arterial tension be thereby increased.

To the above I have been able, with the assistance of my colleague, Mr. Reeves, to add seven cases of carotid aneurism, in which the main trunk was tied; six recovered and one died.

AXILLARY ANEURISM.

Now, for axillary aneurism, of which Case 3 is an illustration. W. T——, aged forty-six, sailor, had been the subject of a quick-growing axillary aneurism on the right side, during three months. It was of the size of a large orange, and caused great discomfort about the shoulder and down the limb. There was no coagulation within the sac.

On March 18th, 1871, I ligatured the subclavian artery in its third part, on the antiseptic plan, with catgut, cut short. March 26th.—The antiseptic condition of the wound has not been maintained. The man died to-day. At a post-mortem examination the catgut ligature is found on the artery, and can be seen in the preparation * made by Mr. McCarthy, and referred to as follows:—The aneurism extended from the upper surface of the first rib to the lower border of the pectoralis minor muscle, and bulged prominently forwards between the upper border of this muscle and the lower border of the subclavius, and backwards into the axilla. Immediately above and below the aneurism the artery was of normal size.

The axillary vein was filled with coagulated blood in the lower third of its course, and in the upper two-thirds was impermeable from the pressure of the aneurismal sac, to which it was firmly adherent.

The cephalic vein and some of its branches, larger than usual, crossed the upper part of the tumour, and appeared to supply the place of the obliterated axillary vein.

The cords of the brachial plexus were closely applied to the upper and back part of the tumour and both heads of the median nerve, but more especially the inner, were compressed by it. The external anterior thoracic nerve crossed in front of it, passing between it and the cephalic vein.

* Lond. Hosp. Mus., C.b. 66.

The commencement of the aorta was considerably dilated. The wall was very atheromatous, and in several parts of it were small secondary dilatations.

The sheaths of the muscles in the neighbourhood of the wound were infiltrated with pus which had spread into the anterior mediastinum. The pericardium was distended with fluid, and its serous surfaces coated with lymph. Both pleuræ contained a good deal of blood-stained fluid. The vessels generally were not markedly atheromatous. Although the post-mortem was made within forty-eight hours after death, decomposition had so far advanced as to render it uncertain whether the viscera generally were unhealthy or not.

Experience shows that ligature of the subclavian in its third part is a very fatal operation, and the surgeon naturally would, unless the case were urgent, postpone that operation in order to try the effect of milder means, if such could be found.

In the above instance the size, rapid growth, and thinness of wall of the sac led me to decide in favour of ligature. Under appropriate circumstances compression, which has already succeeded, should be attempted though it fail; either on account of the insupportable pain connected with it, or by reason of the tendency to slough of the compressed structures. Dr. Peatson, of Manchester, treated a case of axillary aneurism in a male, aged thirty-three, successfully by digital compression during three months. The skin at the points of

compression had suffered much and showed numerous sores. The patient died seven years subsequently, and the obliterated remains of a fusiform aneurism were found. On the other hand, see account of Mr. Cooper Foster's case, cured in five and a-half hours.*

A small slow-growing tumour with firm walls, as though some deposit had already taken place, would be the indication both for compression and for *manipulation* also; the latter a method of treating aneurism, suggested by Sir W. Fergusson, which has been successful. A case of brachial aneurism accidentally cured by this method of manipulation by Mr. F. P. Lansdown, of Clifton, is worthy of record not only as an evidence of cure, but also to put surgeons on their guard against the undue handling of certain aneurisms, and especially of cervical aneurisms, lest embolism result in the vessels of the brain.

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Mr. Lansdown writes me:—"A man, æt. forty-five, presented himself for admission into the Bristol General Hospital, in January, 1866, with an aneurism of the right brachial artery, situated just below the tendon of the pectoralis major muscle. I manipulated it pretty freely, with the view of showing the students how the sac could be emptied.

"The patient was not prepared to come into the hospital then, so he went home and returned after three days. I now found the tumour solid and non-pulsating.

* "Guy's Hosp. Reps.," 1873.

"In six months the tumour was entirely absorbed, a fibrous cord being felt in its place.

"The only apparent cause of aneurism was the use of a crutch under the right arm for twenty-four years."

Another resource, if there were sufficient room, lies in placing a ligature between the clavicle and the sac, but at the risk of inflammation of that sac; a risk justifiable under extreme circumstances and which, as Couper's case of carotid aneurism shows (p. 45), may have a favourable issue. Lastly, the old operation, laying open the sac and placing a ligature on the artery both above and below it. This method has been advocated by Mr. Syme, on the ground that all aneurisms, of whatever size and however caused, have the aperture of communication between the vessel and sac about the middle of this latter. Unfortunately, in one sense, but fortunately in another, as it will prevent error, Mr. Henry Lee has pointed out that most aneurisms of the larger arteries are fusiform; and, consequently, Mr. Syme's suggestion will be applicable to a very limited number of cases. Even then, reserving this limited number to be so treated, is it possible in a given case to predetermine the extent to which the artery is involved in the sac? I should reply in the negative, and certainly would not adopt this operation in the instance of spontaneous aneurism. In my own cases of axillary and inguinal aneurism the form was *fusiform*.* Mr. Syme's second proposition—that

* Lond. Hosp. Mus.

a portion of artery is not necessarily diseased *simply* because it is overlapped by an aneurism, or runs for some distance on its wall—is probably accepted at once as correct, and if so, need not to have been advanced in order to support his resuscitated operation. But it does not follow that for other reasons it is always healthy enough to bear a ligature.

With regard to the selection of a case to which the old operation is at all suitable, I should say, on anatomical grounds, that it is the least so to axillary aneurism. This vessel is surrounded by vessels and nerves in the healthy state, and what their relative positions will be under altered circumstances it is impossible to foresee. Neither can this be known during the progress of the operation in time to avoid injury to important structures, should such lie across the track of the knife.

Again, this artery gives off numerous branches, any one or more of which may bring blood to the sac, and which if not ligatured at the time will probably give rise to secondary hæmorrhage. Even to secure this branch or branches at the time of operation would be tedious and difficult, and would entail great loss of blood. Amputation at the shoulder-joint has succeeded, and might again.

The result of my research concerning ligature of the subclavian in its third part for various true aneurisms is, out of forty-three cases, twenty-seven recoveries, sixteen deaths.

INGUINAL ANEURISM.

I proceed now to consider inguinal aneurism, of which I have had one case.

J. C——, a male forty years of age, was admitted into the hospital on the 26th of August, 1867. Three years ago he slipped and sprained his groin, and a fortnight later the leg and foot became red and the veins swelled, and he noticed a little "beating lump" in the right groin. Compression with and without chloroform had been repeatedly tried in British hospitals without avail. On one occasion he nearly bled to death from an ulcer on the leg.

August 27th.—The limb is much swollen, and the superficial veins as high as Poupart's ligature are distended, and an ulcer exists on the leg. In the right inguinal region is a large pulsating tumour, somewhat constricted by Poupart's ligament. It expands synchronously with the heart's action, and a distinct bruit is both heard and felt. The swelling occupies a great part of the iliac fossa, probably involving the greater part of the external iliac as well as the common femoral artery.

Dr. Sutton recognizes a regurgitant aortic murmur and a large heart, but thinks these conditions do not contra-indicate an operation. Perfect rest in bed was enjoined, and ice locally. The patient was to use the abdominal tourniquet as much as possible,

replacing it now and then by digital compression with his own hands. He thoroughly understood how to use his fingers.

The patient entered the hospital with the determination to have an operation performed, after having fully considered the risk. He even suggested that if the artery for which the ligature was intended proved to be much diseased, the operation need not be completed. He was tired of compression, the method having failed so often.

On September 21st, swelling of the extremity and venous congestion having greatly subsided, and the ulcer having healed, I undertook to ligature the right common iliac artery.

Operation. — The limb having been carefully wrapped in cotton wool, and chloroform administered, I made an incision from five to six inches in length on the right side of the abdomen, from the point of the last rib downwards and forwards to a spot about an inch in front of, and below the anterior-superior spine of, the ilium. The various fasciæ and muscles were separately divided to the full extent of the wound in the skin, and vessels bleeding were at once tied. The peritoneum was readily reached, and with equal ease separated from the iliac fossa by the hand until the vertebral column was gained, and the right common iliac artery was both felt and seen when the wound was well opened. With the finger nail I cautiously, but with difficulty, isolated, as I thought, the vessel

and passed a ligature around it on a common aneurism needle, aided by the sense of touch only. The wound was closed by sutures and strapping.

10 p.m.—Has been in agony with pain of a burning character and cramp in the calf of the leg ever since the operation. No sensation in the foot. Pulse 94; temp. 98; respir. 24. Has taken four doses of liquor opii sedat. and of chloric ether without procuring sleep, but is quieter. Immediately after the operation gentle friction of the hand was to be commenced and continued night and day, and hot bottles were placed in the bed in order to raise the temperature of the air.

September 22nd.—10 a.m.—Dozed a little during the night; severe pain still and cramp; face flushed; conjunctiva injected; pulse 120, full and bounding; temp. 103·4; resp. 32; tongue furred; hiccough; skin dry. The great toe is of tallowy whiteness; no sensation, and loss of muscular power as high as the knee.

12.30 p.m.—Free perspiration; intermittent pulse.

6 p.m.—Perspiring; slight oozing from wound; thirst; has slept a little; the vastus internus is spasmodically contracted.

9 p.m.—Burning pain about the knee-cap; pulse 118; temp. 101·2; resp. 31.

September 23rd.—10 a.m.—Good night; face less flushed; tongue coated white.

3 p.m.—Gangrenous odour; cuticle peeling here and there; the leg is green, and purple, and black

as high as just above the patella, and here a small vein feels hard and is tender; great thirst.

9 p.m.—Looks better, but has not taken his food well to-day; pain in abdomen with tympanitis; tongue and skin moist; pulse 126; temp. 98·6; resp. 24.

24*th.*—The gangrene is extending; no rest night or day; hiccough.

25*th.*—The whole thigh is swollen and dusky; it feels very heavy, as if it were being dragged from him.

26*th.*—Pinched features; abdomen tympanitic; extremities cold and clammy.

27*th.*—Died this morning.

Post-mortem.—The right leg and foot, excepting the great toe, which was pale, were of a greenish black hue; the thigh was of a dark purple colour, as also was the lower third of the edges of the wound whence ligatures protruded. The whole limb was much swollen, being œdematous and crepitating; the cuticle peeled readily. On opening the abdomen the cæcum and ascending colon, as well as the greater part of the small intestines, were distended. The contiguous borders, of some five feet of small intestine, were injected red, and two coils to the left of the umbilicus were glued together by recent lymph. The track of the operative wound behind the peritoneum was indicated by a dark purple line (ecchymosis), and over this the peritoneum was smooth and glistening, except at one spot, where existed a

small patch of recent lymph, easily removable. The peritoneal cavity was not perceptibly opened. The right common iliac artery was cleaned with difficulty, the surrounding areolar tissue being thickened and indurated; and upon the vessel, about its middle, was the ligature, including a small segment of vein, which could only be separated from adhering by the most careful dissection. There was no clot in the vein. The aneurismal swelling involved the greater part of the length of the external iliac artery and the whole of the common femoral; the superficial femoral and profunda arteries were somewhat contracted, and felt full of clot, as they left the sac. The external iliac vein, thought to be completely lost in the wall of the aneurism, was found, on recent dissection, to be pervious, though contracted. The whole circumference of the external iliac artery, and of the common femoral, appeared to be involved in the disease, constituting a tubular aneurism. The aorta generally was atheromatous, and the heart greatly enlarged.

Mr. Syme has advocated and practised the old operation,—laying open the sac, and securing the artery on either side of it successfully. But similar objections apply to inguinal as to axillary aneurism; some with less, others with more force. The chief objection is that the aneurism will probably be tubular, as was the above, and the difficulty in finding the communications with the artery may be insurmountable.

The common iliac vein proved to be included, to a small extent, by the ligature, and yet, although when the thread was tightened a little blood flowed up at the wound, no suspicion of the nature of the injury was aroused. It is worthy also of note that the presence of the thread had not caused coagulation within the vein. It may also be fairly asked how far the adhesion between vein and artery should be ascribed to a frequent repetition of treatment by compression; and would fatal hæmorrhage, or any hæmorrhage, have occurred on the separation of the ligature, supposing the patient to have survived the operation long enough. Of cases of ligature of the common iliac for aneurism I have collected eight, of which two recovered, six died. Had I known, or indeed suspected, that the chief channel for the return of venous blood was contracted other than temporarily, I would have made no attempt by ligature to cure the disease. The recumbent posture and elevation of the foot so diminished the previously existing venous engorgement, and allowed an ulcer to heal, that I quite hoped that by diminishing the bulk of the aneurism by the operation the channel of the external iliac vein would be enlarged, and the obstacle to the return of blood be in great measure removed. As it turned out, no sooner was the ligature applied than the fluids in the limb stagnated, and gangrene resulted. The gangrene, too, was of the moist variety, by reason of the presence of a large quantity of venous blood in the tissue.

In the future, if called upon to treat a similar case, the treatment would I expect be only palliative, or perhaps, as a last resource, amputation above the knee might be performed, with the view of rendering the usual quantity of blood brought to the limb unnecessary, and then possibly the aneurism might shrink.

With regard to the operation, it was performed with comparative ease, the incision allowing the hand to pass directly to the artery proposed to be ligatured, without the risk of encroaching upon and injuring the sac of the aneurism. The post-mortem examination certainly revealed what may be termed a local peritonitis, which appeared to radiate from a spot in the line of progress from the external wound towards the artery, but at the same time no injury to the peritoneum could be detected; nevertheless, without the operation there would have been no peritonitis. Death doubtless arose from shock, consequent on gangrene of the extremity, and of peritonitis.

The common iliac artery may also be tied, as follows :—

LIGATURE OF COMMON ILIAC ARTERIES.

Previous to the performance of operations, which might be rendered difficult by the presence of loaded bowels, a dose of castor oil, followed by an enema of warm water, should be administered. In order also

to relax the abdominal muscles concerned in the operation the thighs may be flexed upon the abdomen, and the head and shoulders also raised and bent forwards.

Anatomical Relations.—These vessels extend outwards from the bifurcation of the abdominal aorta opposite to the lower margin of the fourth lumbar vertebra, to the intervertebral substance between the last lumbar vertebra and the sacrum, at which point they divide into internal and external iliac arteries. Both vessels are covered by peritoneum, and crossed by the ureter at the bifurcation. The relation of veins on either side differs; on the right side the common iliac vein lies behind and external to its artery; on the left side the common iliac vein is at first behind, and internal to its artery, and afterwards behind the right common iliac artery.

OPERATION.

Both the internal and common iliac arteries may be exposed by a proceeding very similar to that employed to lay bare the external iliac (p. 89), the incision being begun about the middle of Poupart's ligament, and carried upwards and outwards, with the convexity looking downwards and outwards, to the extent of about five inches. Similar strata will be divided, and all vessels which bleed should be immediately tied.

POPLITEAL ANEURISM.

I now come to the last of the series of aneurisms, the popliteal, of which variety four have come under my immediate care. They are instructive, because they ran a different course and were treated differently, though successfully. Two were cured by ligature, and two by compression. The most simple method, flexion of the leg (as suggested by Mr. Hart), failed in both instances after a thorough trial of a month in one instance, and of seven weeks in the other; the flexion being very decided during the first fortnight, but relaxed during the rest of the period in the second case.

E. H——, thirty-one years of age, was referred to me in July, 1868, by Dr. J. M. Butler, of Woolwich. An aneurism occupied the lower half of the popliteal space. Extreme flexion was gradually accomplished, and maintained for a month without benefit. A hand tourniquet to be used by the patient, his own thumbs and a ten-pound weight to be used alternately, as much as possible, were substituted. On the twenty-sixth day from the commencement of compression pulsation ceased in the tumour.

R. J——, thirty-three years of age, was seen by me now and then, in consultation with Mr. White, of Dalston, in 1868-69. An aneurism occupied the upper part of the popliteal space. The leg was

thoroughly flexed, and so maintained for a fortnight, and to some extent for seven weeks without avail, while a ten-pound weight was added to compress the femoral at the groin during the last five weeks. From November 30th, 1868, to March 13th, 1869, Mr. White resorted to various methods of compression, but to no good end. We now arranged to try digital compression, aided by morphia. Six gentlemen, students of the London Hospital, compressed the common femoral alternately for ten minutes; and pulsation ceased after the lapse of from twenty-two to twenty-three hours. A day or two later slight pulsation was again noticed in the tumour, but soon ceased.*

The effect of flexion is to compress the aneurism directly in all instances, and possibly in some to crumple it and detach portions of coagulum; in another to moderate the *entrance*; and in a second to moderate the *exit* of blood. One or more of these effects may be looked for in accordance with the size and position of the sac. Should it be large, and correspond to the line of the articulation of the knee, crumpling, and possibly rupture, must be anticipated occasionally, and the more certainly if the aneurism lie between the joint and the artery, when it may burst into that joint and require, at least, immediate ligature of the superficial femoral in one case, ampu-

* This is the brief history of the case of the gentleman who took his meals and enjoyed his pipe during treatment aided by morphia, mentioned on page 15.

tation in another, should gangrene also threaten. A small tumour seated either below or above the line of the articulation will be influenced in one way or the other, as above mentioned. My two cases appeared to me to be suitable for the flexion method, and although it failed, its simplicity demands a fair trial first, under circumstances above indicated. Mr. Spence's case, in which flexion succeeded after ligature of the superficial femoral had failed, is a striking example of its value, even as a last resource; and may here be likened to the use of graduated compression, successfully employed at an original wound, the seat of secondary hæmorrhage, after ligature higher up the trunk has failed (p. 93). It may also be associated with other methods of compression at the groin, as in the cases of R. J—— and E. H——, above mentioned.

The means employed are either instrumental or digital, associated or separately, and all may be used either with a view to obstruct the flow of blood completely or only partially, and for a shorter or longer period, in accordance with the local effect on the skin, the susceptibility of the patient, or the use or absence of a soporific or anæsthetic.

The result of the inquiries which Mr. Holmes has made, concerning the compression treatment, will alter the views of surgeons hitherto held. It appears that the mortality from ligature, after compression has failed, is ten per cent. greater than when the Hunterian operation has been performed at once;

while others were not cured. This fact will naturally lead us to be more discriminating in our selection of the means of cure to be tried first, as well as the length of time during which compression may be continued.* Enlargement of the collaterals is desirable, but must not be promoted to the exclusion of every other consideration.

In the two instances in which I have *tied* the femoral for popliteal aneurism, sudden development and rapid growth in the one, and probably rupture in the other, led me to resort quickly to the ligature, and with success.

One is the case (6) of W. M——, aged thirty-two, sailor (reported by Dr. T. W. T. Smith, of Battersea), who was admitted to the hospital on May 4th, 1872, suffering from femoro-popliteal aneurism. The history of the case given by the patient is as follows:

He received a blow from the sharp end of the handle of a truck on the inner part of the middle third of the thigh, which did not oblige him to discontinue work. The only evidence of injury at the time being a slight aching pain, but the skin afterwards became black. Three weeks subsequent to the accident he was kneeling, and on attempting to rise was seized with cramp at the spot where he received the blow, which lasted about a quarter of an hour. He went to bed, but could not sleep on account of the pain in the lower part of his thigh,

* See papers by Author in *Medical Times and Gazette*, 1869, pp. 269, 380.

and consequently also was unable to resume his duties the next morning. In four days after he noticed a slight swelling in the thigh, and distinctly felt a hard tumour, which pulsated. The tumour was about the size of a large marble. He has been on shore for the last ten days, and during this time the swelling has been increasing, and has caused him more pain, especially at night.

Upon admission, there was a pulsating tumour, oval in shape, about the size of a duck's egg, and situated at the junction of the middle and lower thirds of the thigh. The pulsation was of a distinctly expansile character, and occurring just after the radial pulse, but synchronous with the posterior tibial. The measurement of the thigh in the situation of the tumour was seventeen inches, it being one and a-half inches greater than that of the other thigh. If pressure be made upon the femoral artery in the groin the pulsation ceases and the swelling quickly diminishes, but both return immediately the pressure is removed. If the leg be elevated, and the pressure be made upon the tumour, it can be diminished in size. A bruit is distinctly heard with the stethoscope.

May 10th.—For the last twenty-four hours a ten-pound weight has been applied at intervals to the femoral artery in Scarpa's triangle, and the aneurismal pulsations are more feeble. He complains of pain in the calf of the leg. The use of the weight to be continued.

14*th.*—The weight had to be removed on account of the skin becoming excoriated. The aneurism pulsates distinctly, but does not get larger. Complains of pain in the hip, knee, and calf of the leg.

17*th.*—A sudden pain seized him on the 15th, the swelling got quickly larger, and the pulsation less strong. He complained of a great deal of pain, from the front of the thigh to the knee. 2 p.m.: Mr. Maunder thought that the sac had given way, and advised the patient to have the femoral artery ligatured. He consented, and Mr. Maunder made an incision about three inches in length, from one and a-half inches below Poupart's ligament downwards and inwards at the inner edge of the sartorius, where the artery was felt to be pulsating. A carbolic catgut ligature was passed round the vessel, the wound was washed out with carbolic water, and the edges brought together by carbolic sutures, and a piece of "protective" was placed over the wound, and carbolic muslin covering the whole; the foot and leg were wrapped in cotton wool and bandaged. 8 p.m.: Patient has vomited since the operation; he complains of a smarting pain in the wound, and aching pains in the knee. Temp. 99; pulse 98; resp. 16.

18*th.*—Passed a comfortable night, no pain in his leg, but complains of a great deal across the lower part of his back. Skin natural, tongue moist, and covered with a white fur. Says his toes

feel rather numb, they are also cold. No pulsation in the tumour. Temp. 100; pulse 84; resp. 21. Evening: temp. 99; pulse 84; resp. 18.

19*th*.—Passed a fair night. Not so much pain in his back. No pain in the leg. No pulsation in tumour nor posterior tibial. Foot and limb quite warm; wound has healed by *first intention*, and the first dressings were not renewed. Temp. 100; pulse 72.

21*st*.—Slept very well; shooting pains from seat of aneurism to knee occasionally. Foot perfectly warm. Measurement of aneurism half an inch less than before operation. Temp. 98; pulse 90.

22*nd*.—Doing well.

25*th*.—Measurement half an inch less than before.

29*th*.—Measurement about the same. No pulsation. Tumour soft and fluctuating.

July 16*th*.—During three or four weeks subsequent to operation very little change occurred in the character of the tumour. It diminished very slowly indeed, and remained soft and fluctuating. The limb was then carefully bandaged from the foot upwards, and in addition a compress of lint was applied over the swelling, and pressure cautiously exerted upon it. In a fortnight the evidence of the previous presence of fluid had disappeared.

The man left the hospital to-day.

Sequel (reported by Mr. Wallace Drew, H.S.).—Re-admitted September 11th, 1872.

History.—For some little time subsequent to

operation he experienced in his leg, formication, chilliness and deadness. These sensations gradually disappeared, and now he has a throbbing in his chest with occasional faintness and giddiness. Pulse 48; temp. 98; resp. 18. Dr. Sutton is requested to see the case on September 15th, and reports: Heart's dulness natural, and no alteration of the apex beat; rhythm is regular (at present the action is normal, although usually the pulse is down to about thirty beats a minute).

There is a well-marked harsh systolic murmur, heard loudest over the sternum, corresponding to the third rib or intercostal space. A very short diastolic murmur is also heard, but it is much less marked, and apparently concealed by a loud clicking of the second sound; the murmurs are conducted to apex.

Apparently there is no systolic mitral murmur, *i.e.*, none heard at the angle of the left scapula.

The systolic portion of the murmur is conducted along the aorta, but in this position it gets less and less distinct as you follow the course of that vessel.

N.B.—The systolic murmur is much longer than the diastolic, and the heart being of natural size is in favour of aneurism, and probably near the base of this organ. The generally peculiar attacks of slow beats, taken with physical signs, lead one to suspect aneurism of the coronary artery; and pain in the epigastrium with the vertigo, show that the heart tends in these paroxysms to stop.

September 16*th*, 17*th*, *and* 18*th*.—On these days, each morning between 4 and 9 a.m., the patient has had several attacks of faintness and giddiness. On the 17th he felt a severe pain about the heart, which for a time seemed to prevent his breathing.

19*th*.—Has felt nothing more of the pain in the cardiac region.

21*st*.—No pain, but a sinking feeling in the epigastric region.

25*th*.—Had several fits of trembling at the pit of his stomach yesterday afternoon.

26*th*.—Tremblings at the pit of the stomach; throbbing pain in the head; no giddiness.

27*th*.—Throbbing pain in head persists; complains of a "scalding pain" in the right knee.

30*th*.—Neuralgia in right side of face and temple disturbed his rest; great throbbing in the abdomen.

October 1*st*.—Great weight and throbbing at epigastrium. Died a few days later.

The post-mortem record is supplied by Mr. W. Lang, H.S.

The body was well nourished.

In the upper third of the right thigh, over the femoral artery, was a linear scar.

On cutting down through this scar a fibrous cord was found, with the femoral vein beside it.

The artery was then removed, and on dissection was found patent down to the division of the common femoral into its superficial and deep

branches. The latter was cut off close to its origin in taking out the specimen, but what remained was patent.

The superficial femoral was represented by a solid cord of fibrous tissue, which was considerably smaller than an ordinary artery, and would be correctly represented by a normal femoral rolled up so as to obliterate its channel. Fibrous tissue connected this cord intimately with the accompanying vein, which latter seemed normal in its whole extent; and even opposite where the ligature was supposed to have been, its coats were not thickened.

The superficial femoral was traced beyond the popliteal space, but as far as it was traced it remained a solid fibrous cord; and even in Hunter's canal, where the aneurism had been, the size of the cord was the same as elsewhere.

On opening up the common femoral one could not pass the scissors into the superficial femoral, and therefore a section was made with a knife and its solidity proved.

No trace of the ligature could be found, but its seat was thought to be at a point where the femoral artery was more intimately bound to the vein. As regards the chest, there was a small aneurism immediately above the aortic valves the size of a walnut, and close to the origin of one of the coronary arteries. Heart healthy.

The other is the case (7) of W. C——, aged forty-two, the subject of a rapidly-growing popliteal

aneurism. I tied the superficial femoral on June 16th, 1872, and in due time the patient was convalescent.

In the latter instance compression was not attempted, and in the former, though commenced, it was quickly omitted because the weight had irritated the skin, and it was while time was allowed for repair of this slight injury that the tumour, a small one, yielded.

Notwithstanding the above-mentioned mortality (p. 63), Mr. Holmes finds "that allowing for accidental circumstances, the results of the two methods, compression and ligature, have been as nearly identical as is possible in a long series of cases extending over many years, and a large variety of districts. . . ." "The total number of deaths was about 14·1 per cent., many of the deaths being due to disease of the heart and viscera."

Seeing that our knowledge of the value of compression is limited and crude, and that already a very large proportion of cases is cured by this method, and a cutting operation with its possible dangers avoided, a still larger percentage of recoveries may be fairly anticipated with increased experience. Having mentioned that *prolonged, gradual*, and *intermitting compression* may either retain the aneurism *in statu quo* or favour ill-success altogether; so also it must be borne in mind that *rapid* compression is sometimes followed either by a return of the disease, or by suppuration and sloughing of the sac. Of about

106 cases of popliteal aneurism that I have gleaned, in which compression was tried, it was necessary to resort to the ligature in fifty-six instances; forty-seven recovered, and nine died. Of the remaining fifty at least nine failed, and were either submitted to amputation or died; forty-one were cured.

Notwithstanding a more extended observation of popliteal aneurism, I repeat now, almost verbatim, what I published* in 1869:—

The mode of treatment which I advocate for the cure of popliteal aneurism and all other suitable cases, is moderate compression, alternating with relaxation, say for a fortnight, with a view partly, if thought desirable, of promoting a more free collateral circulation in the limb; and at the expiration of this time, *continuous* compression, either digital or instrumental (completely obstructing the artery), maintained under chloroform or opium, if necessary, for a period of from six to twelve hours or even longer, and assisted by a tourniquet on the distal side of the sac, if the first attempt did not succeed. Should a few sittings fail to effect good progress in the aneurism, the ligature must be resorted to.

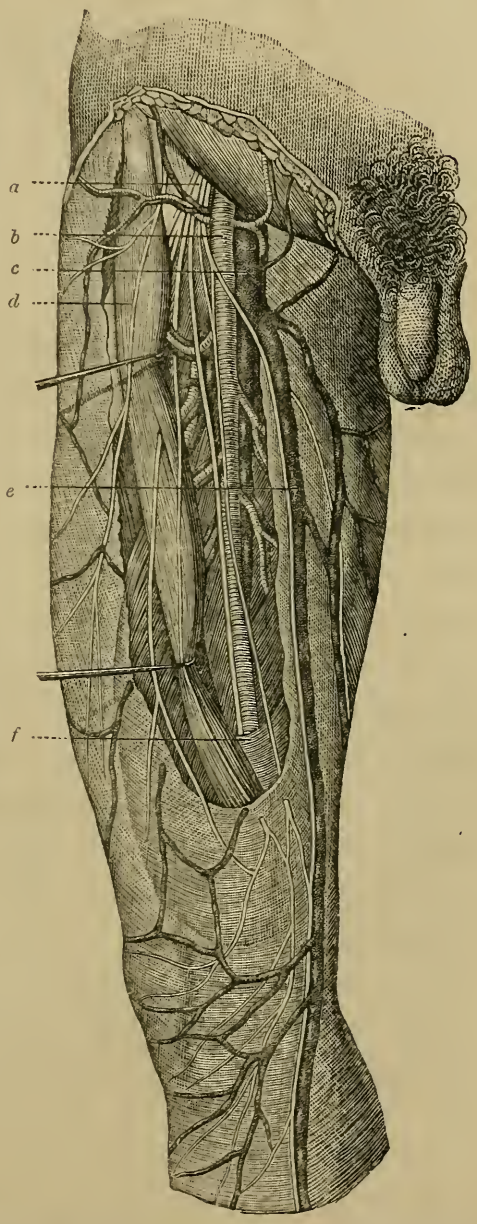
LIGATURE OF THE FEMORAL ARTERY.

Anatomical Relations.—This vessel (Fig. 4) extends through the upper two-thirds of the thigh, from the centre of Poupart's ligament to the opening

* *Med. Times*, 1869, p. 269.

in the adductor magnus muscle, through which it passes to become popliteal. On the surface, the thigh being abducted and rotated outwards, a line drawn from the centre of Poupart's ligament downwards and inwards, along the front and inner side of the thigh to the centre of the popliteal space will indicate the course of the artery. In the upper third of the thigh the artery (*b*) traverses Scarpa's triangle, from the centre of its base to its apex, and is covered in by skin, superficial fascia, which at the upper and inner parts consists of at least two layers, with superficial

Fig. 4.



vessels and lymphatic glands intervening, and fascia lata; one or two branches of the anterior crural nerve cross the artery from without inwards. On the outside, at the distance of about half an inch, lies the trunk of the anterior crural nerve (*a*), two large branches of which gradually approach the artery. On the inside, and not closely applied to the artery at first, is the femoral vein (*c*), which lower down is found posterior to the artery, and only separated from it by a very thin cellular septum. Behind the artery are certain muscles and portions of the profunda artery, profunda vein, and of the femoral vein. The profunda artery usually arises at the distance of about one inch and a-half below Poupart's ligament, from the posterior and outer side of the femoral artery, and pursues a course outwards, downwards, inwards, and then again downwards, parallel to but deeper than the femoral artery, thus forming a curve external to the femoral artery, and leaving a space between the two vessels through which a knife might pass without wounding either of them. The fact is worthy of recollection in reference to wounds of the arteries of the thigh. It should also be borne in mind that a stab in a certain part of the thigh might transfix both femoral and profunda arteries.

OPERATION.

The femoral artery can be ligatured in any part of its course, but with comparative ease in Scarpa's triangle. In a case of popliteal aneurism, requiring ligature of the main vessel, the *point of selection* for ligature is the apex of Scarpa's triangle, corresponding to the convergence of the adductor longus muscle from the inside and the sartorius muscle (*d*) from the outside. This situation is preferred, because the artery is comparatively superficial, at a moderate distance from a large branch (profunda), through which, if nearer, the current of blood flowing might prevent union of the divided coats, and the formation and organization of a firm clot to plug the vessel; the profunda artery being also above the ligature, the nutrition of the limb is not interfered with in a dangerous degree.

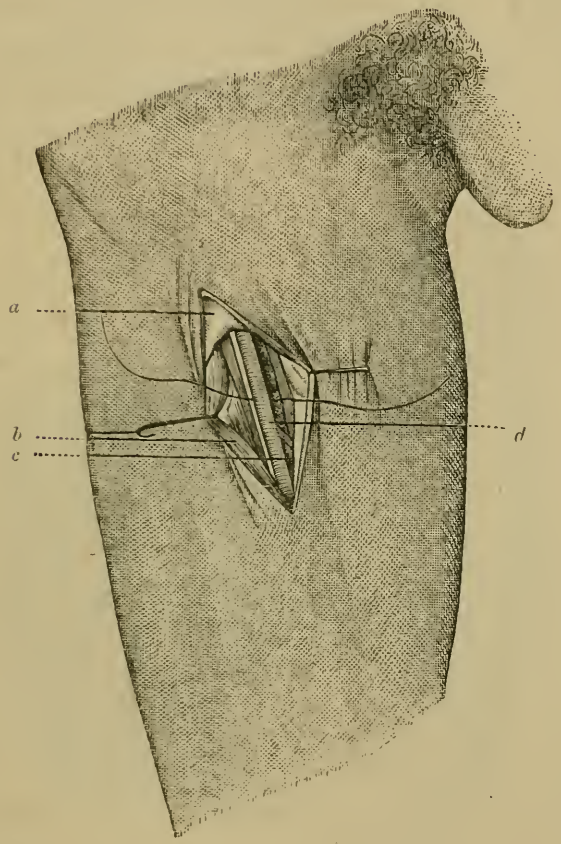
Ligature at the Apex of Scarpa's Triangle.—The patient being recumbent, with the leg partially flexed upon the thigh, and the thigh slightly abducted and rotated outwards, the position of the internal saphena vein should be ascertained by making pressure upon it near its junction with the femoral vein, so as to check the flow of blood through and cause it to swell; the position also of the sartorius muscle, especially the inner margin of the upper portion, which borders the artery and

crosses the thigh from above, inwards and downwards, should be ascertained by causing the subject, if living, to bring the muscle into action. The part having been shaved, if necessary, and the course of the artery known by its pulsation, if the subject be alive, and by the surface line indicated above, an incision commenced at a distance of four fingers' breadth below Poupart's ligament should divide the integuments only, parallel to the artery, to the extent of three inches, leaving the saphena vein on its inner side; any lymphatic glands intervening should be held aside or removed, while the deep fascia is divided on a director. Seek now the inner margin of the sartorius muscle, the fibres of which run downwards and inwards, and along this border, or just under cover of it, the artery will be seated. The sheath of the vessel having been opened as directed,* the aneurism needle must be passed with the utmost care around the artery from within outwards, the point of the needle being kept closely applied to the artery, lest the vein—which in this locality is particularly near the artery, and generally behind it—should be wounded. (I have repeatedly seen the vein wounded, and a segment of it included with the artery, where ligature of the femoral artery has been practised, by gentlemen attending my "course of operations" in Paris.) Fig. 5 shows the incision and parts interested in the above operation. The integuments are divided, as

* See "Operative Surgery," 2nd ed., p. 41, by C. F. Maunder.

also the deep fascia (*a*); the sartorius muscle (*b*) is pulled to the other side, exposing the artery (*d*) and the vein (*c*).

Fig. 5.*



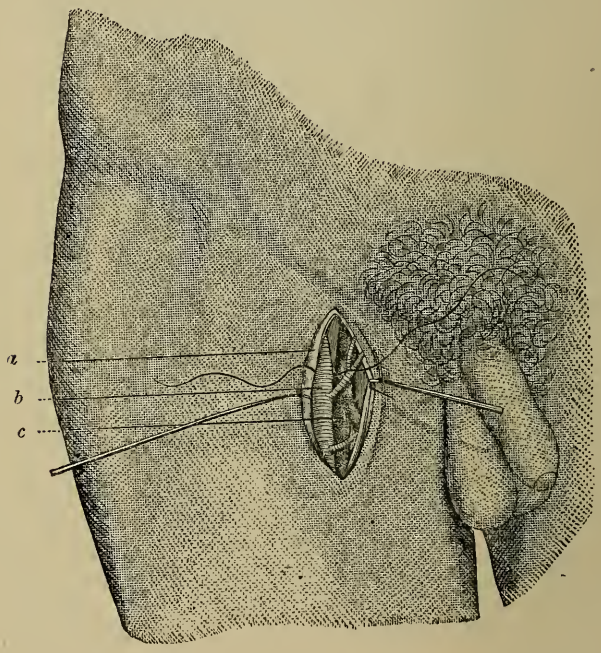
Ligature at the Base of Scarpa's Triangle.—In this position the artery is superficially placed, being covered in by skin, superficial fascia, lymphatic glands, cribriform fascia, or deep fascia, having the trunk of the anterior crural nerve on the outer

* The nerve is much too near the vessels.

side, about half an inch from it, the femoral vein on its inner side occupying the central partition of the crural sheath, but separated from the artery by a distinct and moderately firm cellular septum.

Make an incision in the direction of the artery already indicated, commencing at Poupart's ligament, and terminating two inches below it, dividing

Fig. 6.



the skin, and then the layers of fascia on a director, till the sheath be reached; open the sheath and pass the aneurism needle from within outwards. The vessel will thus be ligatured midway between the origins of the deep epigastric and deep circumflex ilii arteries, branches of the external iliac artery

above, and the profunda artery, the largest branch of the femoral artery below. Fig. 6 shows the parts exposed by the above incision; *a* is the deep fascia, *b* marks the artery, and *c* is the femoral vein, internal to the artery, and separated from it by a distinct septum, a portion of which is seen in the figure. Any superficial artery which bleeds during the operation should be immediately ligatured or twisted.

GENERAL CONCLUSIONS.

After a review of my experience, briefly and imperfectly stated above, as it necessarily is, I come to the following conclusions: —

1. That no case of aneurism is to be regarded as necessarily incurable.

2. That some cases of internal aneurism are apparently cured by absolute and prolonged rest, restricted diet, and other medical treatment.

3. That, when possible, compression, either proximal or distal, is to be employed in addition.

4. That in all aneurisms in which treatment by ligature is known to be a very fatal operation, the above rules are to be first applied.

5. That the treatment, of progressive aneurism at the root of the neck, by the distal operation, is justifiable after medical treatment has failed.

6. That in rare instances only may an aneurism be treated by ligature before compression has been tried, and has failed.

7. That digital is to be preferred to instrumental compression.

8. That anæsthetics and morphia are valuable aids to compression.

9. That chloroform will probably prove to be a more effectual agent than morphia in all cases, but the more hazardous.

10. That the value of morphia should be more thoroughly tested.

LECTURE II.

ON WOUNDS, HÆMORRHAGES, AND THE ANTISEPTIC LIGATURE.

Observation in man and experiments on the lower animals* have shown that, although there is some analogy in the method of repair in arteries wounded in their continuity, yet natural efforts can be much more rarely relied upon for the repair of injury in the former than in the latter.

As many as nineteen cases of wound and of hæmorrhage have come under my care in which ligature of an artery in its continuity has been resorted to.

In endeavouring to arrive at a conclusion as to the vessel wounded and the nature of that wound, the position of the patient at the time of the receipt of the injury, the kind of weapon employed, direction given to it, and both the amount and rapidity of the loss of blood should be investigated. In certain regions (as in Scarpa's triangle) where several large vessels lie near each other (Fig. 4. p. 73) it should be borne in mind that a knife

* Dr. Jones "On Hæmorrhage," 1805.

might pass between the superficial femoral and the profunda without wounding either, or it might involve both. Supposing, then, a wound to have been received in the groin, followed by free hæmorrhage, but which had ceased either spontaneously or by some simple means before the arrival of the surgeon, the dictum of Guthrie—that no artery is to be tied unless it bleed—is to be followed, provided that the safety of the patient can be secured by special means.

Stab of Groin.—A young man is stabbed in the groin; and bleeding, which is severe, ceases spontaneously. My house-surgeon, Mr. Stanley Gill, puts him to bed, with a compress and bandage on the wound, and with a watchful attendant by his side. Hæmorrhage does not occur, and the patient is soon convalescent.

Incised Wound of Forearm.—Dan. L——, æt. forty-two, was repairing a roof, when his foot slipped, and his right arm went through the skylight.

On admission, October 10th, 1872, there was a deep, narrow wound on the inner and back part of the forearm at the upper third. Hæmorrhage had been profuse, and the man was blanched. Mr. Maunder chanced to be "going round" at the time, and he enlarged the wound superficially with the hope of finding the bleeding vessel. This was not seen, and to avoid the alternative of laying open the forearm very freely to make further

search, it was determined to try compression. This was very carefully done, by Mr. Wallace Drew, house-surgeon, by means of a compress of lint extending the whole length of the forearm, both back and front, sustained by a suitable bandage. Perfect rest was enjoined, bleeding did not recur, and the patient was soon convalescent.

Shell-wound of Knee.—In the Crimea, on November 18th, 1855, I amputated the thigh of an artilleryman, B. H——, who had sustained a contuso-lacerated shell wound of the knee-joint. The inner tuberosity of the tibia was also fractured.

November 24th.—A slight oosing of blood occurred this morning. I placed a tourniquet in apposition in case of need.

25*th.*—Hæmorrhage to the extent of six or eight ounces occurred to-day, and was arrested by the tourniquet.

29*th.*—Hæmorrhage recurred to-day to the extent of about four ounces, and was checked by the tourniquet firmly applied.

30*th*, 4 *p.m.*—The hæmorrhage has returned, and is again stopped by the tourniquet.

December 1st.—The patient's powers are much reduced.

It was agreed that the tourniquet should be removed, and if bleeding come on a ligature was to be applied to the femoral artery at the lowest point at which pressure commanded the hæmorrhage. Accordingly the tourniquet and dressings

were removed; and, although the stump was purposely rather roughly handled, no recurrence of bleeding took place.

15*th*.—He bled no more, but died to-day with symptoms of pyæmia.

Autopsy ten hours after death.—The deep parts of the flaps were adherent except at the end of the bone; and extending upwards for about two inches an abscess existed, into which the femoral artery and vein projected. The vein was found to contain pus as high up as Poupart's ligament. The artery, to the extent of half its circumference and about one inch of its length, had sloughed; but for about one inch and a-half above this diseased portion the artery was occupied by a conical and mottled coagulum, the small end of the cone looking towards the heart. Guthrie's dictum was carried too far in this instance. The repeated loss of blood, doubtless, led indirectly to a fatal result.*

Wound of Groin.—On the other hand, this preparation,† showing the superficial femoral and profunda arteries and their companion veins wounded, indicates what a vast amount of injury may be inflicted on blood-vessels with a temporary arrest of hæmorrhage. The man was admitted with a small longitudinal wound of the groin, probably not more than three-quarters of an inch in length, and when seen bleeding had ceased. The

* "Lond. Hosp. Reps.," vol. iv. p. 264.

† Lond. Hosp. Mus., C.b. No. 94.

instructions given were that the patient should be watched, and the bleeding be controlled if it recurred by closing the wound with the finger while the surgeon was being sent for. Bleeding did return; but the surgeon was not sent for. The house-surgeon enlarged the wound in order to find the bleeding vessel; and a glance at the preparation will show what difficulties he must have had to contend with, both arteries and veins being wounded. The position was one calculated to test the capacity of an experienced surgeon. The patient died quickly from loss of blood.

But instances are not uncommon in which from the position of the wound, and the great amount of blood rapidly lost, it is tolerably certain that a large vessel has been opened. And while bleeding may have ceased for the moment, either by reason of the simple means employed in the shape of a handkerchief tied round the limb, or by the application of a tourniquet, or by the weakened condition of the circulation, yet we believe it will recur either on the removal of these appliances, which cannot be long borne, or when reaction sets in. Under these circumstances delay is dangerous, *for time is blood*, provided the opportunity be given for hæmorrhage to recur as the signal for operative interference.

Wound of Thigh.—R. P——, aged nineteen (Case 10*), accidentally wounded his left femoral artery with a penknife. I was quickly by his side,

* See Table of Arteries, p. 2.

accompanied by Dr. W. R. Woodman, now of Alphington. A colleague of my patient (Mr. E. J. Dixon) had the presence of mind to arrest bleeding, which had been very severe, by tying a pocket handkerchief round the limb. As the young man lay in the Provincial Bank of Ireland, the scene of the disaster, I proceeded to search for the wounded vessel, and found it to be the superficial femoral *artery*. I placed a ligature above and below the wound in it, and while doing so Dr. Woodman and I established beyond the possibility of doubt, that *venous* blood flowed from the artery on the distal side of the wound in it. A similar observation has been made by Guthrie, and Mr. Cæsar Hawkins has recorded it of the *brachial* artery.* The patient recovered.

Contuso-Lacerated Wound.—Case 11. J. L——, twenty-eight years of age, of intemperate habits, fell upon a railing spike, tore his superficial femoral artery, and lost a considerable quantity of blood. I secured the wounded vessel with a double ligature. The thigh about the wound became extensively gangrenous, and the man died on the tenth day. The extremity of the limb showed no sign whatever that its usual vascular arrangement had been interfered with.

I have been able to trace nine additional cases in which the femoral was tied for wound and traumatic aneurism. Of these six recovered, and three died.

* "Contrib. to Path. and Surg.," vol. ii. p. 339.

Independently of the necessity for immediate operation which these two cases illustrate, the fact that in one case (10) venous-looking blood flowed from the artery below the wound in it must not be lost sight of. Even in *primary* bleeding blood, though venous, coming from the distal side of the wound is a favourable sign, indicating that the circulation is equal to the maintenance of the vitality of the limb; but in *secondary* hæmorrhage, following the wounding or ligature of an artery (femoral for example), the colour of the blood is a matter of the highest import. Experience has shown that repair can be more certainly expected to occur on the proximal than on the distal side of the ligature on an artery; and, consequently, when secondary hæmorrhage does arise, to know whence it comes is of the utmost value to the surgeon. Should the blood be arterial and proximal little else than the application of a ligature higher up the trunk (with a possible repetition of bleeding or even gangrene of the limb) will suffice to arrest it occasionally. But the prognosis will be much more favourable if the blood be of a dark colour (the blood flowing from the distal end is not necessarily venous), when rest and the local application of cold and pressure will be effectual. It so happens that in no case of my own has secondary hæmorrhage resulted, but the above remarks are well illustrated by the following case of Mr. Couper's.

On September 18th, 1867, Mr. Couper ligatured

the right external iliac artery, above the origin of the deep epigastric and circumflex ilii arteries, for femoral aneurism, in a male aged thirty-one. On the evening of October 8th the ligature came away. At 1.30 a.m. of October 9th, and soon after straining at stool, hæmorrhage from the wound of a venous colour occurred. This was stopped in a few minutes by the application of ice. At 5 a.m. the patient moved a little in bed and bleeding recurred, and ceased again on the application of ice. This was continued till 5 p.m., and at the same time a lead weight, 2½lbs., was applied over the aneurism, which on the day the ligature came away was found to be pulsating. Bleeding did not return, but the pulsation was appreciable when the man left the hospital on December 21st.

LIGATURE OF THE EXTERNAL ILIAC ARTERY.

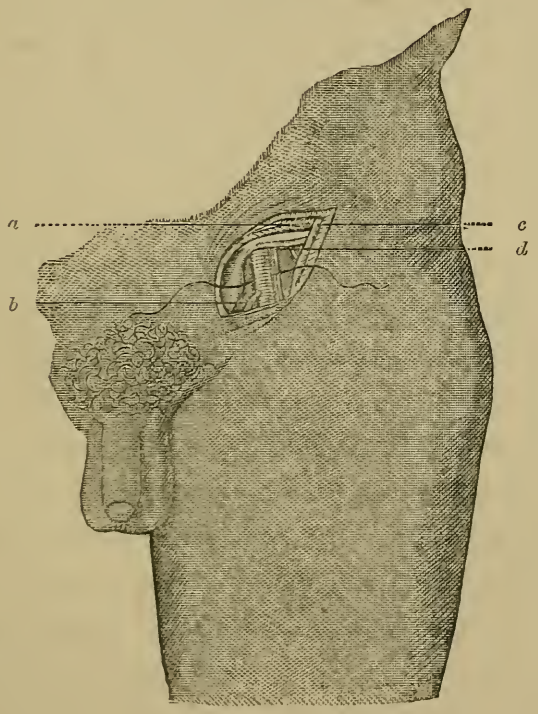
External Iliac Artery. Anatomical Relations.—This vessel extends downwards and outwards from the bifurcation of the common iliac artery, lying along the inner border of the psoas muscle to the centre of Poupart's ligament; internal to and behind it is the external iliac vein; running upon it sometimes is a branch of the genito-crural nerve; near its termination, or about half an inch above Poupart's ligament, two large branches arise, deep epigastric and deep circumflex ilii arteries; the vein accompanying the latter artery crosses the external iliac artery

from without inwards to join the external iliac vein. The artery is covered by peritoneum, and some lymphatic glands are adjacent to it.

OPERATION.

Ligature of the External Iliac Artery. — This vessel is best reached by an incision, begun about half an inch above Poupart's ligament, at the junc-

Fig. 7.



tion of the inner and middle third of the space between the symphysis pubis and the antero-superior spine of the ilium, and carried outwards to the

extent of three inches towards the antero-superior spine of the ilium, parallel to Poupart's ligament. Divide thus the integuments, the aponeurosis of the external oblique muscles (Fig. 7) (*c*), raise or divide the fibres of the internal oblique and transversalis muscles (*a*) on a director; let an assistant hold aside the cord, and slit up the transversalis fascia also on a director; with the fingers carefully push up the peritoneum (*d*), and seek the artery above the origin of the deep epigastric and deep circumflex ilii arteries; a branch of the genito-crural nerve will be occasionally seen upon the vessel. The aneurism needle should be passed from within outwards, avoiding the external iliac vein, the deep circumflex ilii vein, and the genito-crural nerve. Fig. 7 shows the external iliac artery (*b*) exposed, the origin of the deep epigastric artery and the genito-crural nerve, in this instance outside the main artery, and the external iliac vein, internal to its companion vessel.

My two cases (10 and 11) also show that, at the ages of nineteen and twenty-eight, the superficial femoral may be suddenly and permanently obstructed without the supervention of gangrene at the extremity of the limb. The case which died is especially instructive, as it shows the capability of the collateral circulation to maintain the life of the limb, while at the same time the wound of the thigh becomes gangrenous, and the patient dies from general exhaustion directly connected with

great loss of blood. Such a state of matters cannot but lead us to believe that a power to dilate and contract is vested in the smaller vessels and capillaries of a limb independently of the reliance of the limb upon the nervous and vascular centres. The experiments of Putzy and Tarchanoff already quoted in Lecture I., p. 20, support this view.

It will sometimes happen that an important artery being opened the skin wound heals quickly and hæmorrhage is prevented, or an artery may be torn without external wound. And although there are on record instances of punctured wound of an important vessel healing, yet, as a rule, under both of the above conditions a traumatic aneurism is formed. Of such cases four have come under my observation, no two alike.

The chief point always to be kept in view in the treatment of these cases is, that we have a *wounded* artery to deal with, and often either no sac or an ill-defined one; and it is in consequence of the absence of a sac, such as is met with in cases of *true* aneurism, that the Hunterian operation is here inadmissible. In true aneurism the maintenance of the blood within certain limits, and the contraction of the sac either after ligature or during treatment by compression, are powerful aids towards cure, neither of which may exist to a useful degree in traumatic aneurism.

Herein lies the difference in the method of treatment in the two classes of cases.

In both we will assume that the collateral circulation is sufficiently established, but in true aneurism the sac maintains the continuity of the artery at the seat of disease, while in the case of wound there is no sac and extravasation spreads. Notwithstanding this important distinction, traumatic aneurisms must practically be classified as circumscribed and diffused. In the former the blood coagulating forms a barrier to any further extravasation, and the surrounding structures becoming agglutinated help in the same direction, and thus an adventitious sac is formed; a pathological condition which may be taken advantage of, and the case be treated either by compression, direct, indirect, or both, or by ligature, on the principle either of Hunter or of Anel. For my own part, I am not much in favour of either of these methods, except in reference to the hand and foot, supposing compression to fail, because the application of a ligature other than at the seat of injury would tend to obliteration of the artery at two points. But supposing search at the seat of injury to be unsuccessful, as is not unlikely to be the case, and graduated compression and bandaging, once repeated at the wound, to have failed, what then? The vessel must be secured higher up. In very many instances when the external iliac (for example) is tied, for secondary hæmorrhage at the original wound in the thigh, bleeding may be expected to recur, and, indeed, should be antici-

pated by the surgeon, who will then be prepared to re-apply that pressure which had previously been of no avail, but which now is very likely to succeed. This operation has been condemned as absolutely useless* because, as a rule, hæmorrhage in many instances (gangrene in a few) have followed it; and then it has been found that in the event of bleeding at the original wound compression has been successful, and the patient has been saved. *Now I should contend, always supposing that the hæmorrhage had been proximal, that the two facts associated (ligature of the external iliac followed by compression) render it a most justifiable operation, because although compression to arrest bleeding from the femoral is useless before, yet it will often succeed after ligature of the artery.* The reason is clear. Before the operation the blood is thrown with force by the heart upon the proximal end of the ligatured vessel, and readily dislodges a clot, or overcomes other obstacles. Thus the flow of blood is direct; but with the second ligature intervening the heart and the first ligature, the force of the circulation is considerably spent, the blood arrives by a circuitous course, and Nature's efforts at the seat of wound in the artery, even on the proximal side, are sufficient to withstand, *with compression added*, the impact of the blood. Thus the dangers of hæmorrhage from the proximal side of a first ligature are rendered as equivalent, as may be, to bleeding from the distal side of the same.

* W. H. Cripps, "Barth. Hosp. Reps.," 1874.

Another very important difference between true and traumatic aneurism consists in the probability that in the case of the latter the artery may be healthy, while in the former it is very liable to be diseased; a circumstance which led Hunter to place a ligature at a distance from a true aneurism.

Without doubt it will often be much easier to apply a ligature to an artery comparatively superficial and lying amongst healthy tissues, than to lay open a blood-cyst deeply seated, and to search for the wounded vessel amid structures condensed and bloodstained. But when this is effected, all anxiety as regards the persistence of the aneurism is at an end. At the same time it must be allowed that a suppurating cavity is insured, while should ligature at a distance be resorted to, suppuration of the swelling, which does occasionally occur, is far from being a necessary sequence. Of my four cases of traumatic aneurism two may be regarded as circumscribed.

Wound of Palm.—Albert P——, aged eighteen, accidentally wounded the palm with a dinner knife. Free bleeding occurred, which was arrested by binding up the hand with an application of Friar's balsam. The wound closed, but a small swelling arose, and bleeding recurred on the eighteenth day from a slight blow on the part. It was now dressed for a few days with compress and bandage, on the removal of which, November 7th, 1865, hæmorrhage returned. I now saw the case in consulta-

tion with the late Dr. Emmott, of Egham. The patient was put to bed, and after clearing away both laminated fibrin and recent blood clot, the bleeding vessel could not be secured. A small piece of sponge was applied to the spot whence the blood seemed to flow, graduated compresses next, and over these a roller grasped by the hand, was firmly fixed by a bandage.

Rest in bed was enjoined.

These dressings were removed on the fifth day from this gentleman's wound, and no further bleeding occurred.

Many years have now elapsed, and the hand is a perfectly useful member, as the patient will show you to-night.

In five other recorded cases the sac of the palmar aneurism was opened; three died of hæmorrhage, and two recovered.

By thus flexing the joints of the wrist and fingers, the long tendons and the digital processes of the palmar fascia allow the bleeding vessel to be more thoroughly pressed between the compressing body and the metacarpal bones than they would be if the fingers and the hand were kept extended. With regard to putting compresses into a wound to arrest bleeding, the following should be the rule. If the parts concerned are very complicated either in structure or function, and the injury be a punctured wound, its depth incapable of exploration with a view to securing the vessel, the first com-

press is not to be forced down to the bleeding point; but all are to be applied to the surface and there maintained, with the addition of methodical bandaging of the entire limb. But should bleeding return, the treatment adopted above for secondary hæmorrhage may be resorted to once or twice previous to the proximal ligature of the main artery.

The second (Case 16 in the Table), *stab of the brachial artery at the bend of the elbow*, was referred to me by Mr. Owen, of Leatherhead. The wound had been inflicted ten days prior to my seeing the patient, and during this period bleeding had occurred once. A small delicate cicatrix surmounted a pulsating swelling of the size of a walnut. A radial pulse existed. The swelling was laid open, and at the bottom of a small cavity the brachial artery was found with a longitudinal slit in it. Arterial blood flowed equally freely from above and below the wound. A double ligature arrested the bleeding, and the patient was soon convalescent.

I have records of four other cases of ligature of the brachial for wound and traumatic aneurism of the vessel itself, and all recovered. The cure of cases such as these may doubtless be sometimes effected by compression, both direct and indirect, aided by methodical bandaging of the whole limb, associated with a suitable position, flexion of the forearm upon the arm, for instance. But when the tumour is superficial and the wound

scarcely healed, the more certain and quickly efficacious method is that by double ligature, or torsion at the seat of injury.

The third and fourth examples of traumatic aneurism were of the diffused variety.

Case 24. *Dislocation at Shoulder, Traumatic Aneurism, Ligature of Axillary Artery*—is that of a man seventy years of age, whose armpit became greatly swollen within two hours of the reduction of a dislocation at the shoulder. About two months subsequently a slough formed in the floor of the axilla, and hæmorrhage occurred twice in one day; the second time to the extent of ten or twelve ounces, and sufficient to prostrate the old man. As a forlorn hope, I determined to endeavour to secure the bleeding vessel, but not without stating that the patient might die during the attempt. The armpit would of course be found greatly distended and undermined by extravasated blood. It was impossible to predict the position of the bleeding point, and it would be very difficult to discover and secure it in a locality traversed by many arteries, and much disorganized. It was scarcely possible to control hæmorrhage by compression of the afferent vessel, and it seemed that the only hope of securing the wound and avoiding further bleeding, was at the moment when the patient was faint from loss of blood.

Operation. July 7th, 1872.—Plugging the wound with my fingers and thumb, held in the obstetric

position, I laid open the axilla by degrees, from base to apex, by dividing the structures forming its anterior wall in a line parallel with the great nerves and vessels of the region. The contained blood-clot from about these was rapidly cleared away and the plexus of vessels and nerves was at once seen, as it were, dissected out by the blood which had permeated the space. I presently discovered a wound in the axillary artery, and applied a double ligature. Hæmorrhage did not recur, but the patient died the same afternoon. (Six weeks after the accident a feeble pulse could be felt at the wrist, but blood did not flow from the distal side of the wound in the artery at the time of operation.)

An accident of this kind happening to a comparatively *young* person could not but be regarded with anxiety, but at the age of seventy must be looked upon as almost beyond the aid of surgical art; and while the surgeon, fully impressed with this idea, might be slow to recommend operative interference, which would probably shorten his patient's days, yet when the tumour had burst, and hæmorrhage occurred almost in his presence, he could hardly be expected to stand calmly by, and make no effort to prevent further bleeding.

The operative proceedings which are open to the surgeon in a case of diffused traumatic aneurism of the axillary artery, are ligature of the subclavian; ligature of the vessel at the seat of injury; amputation at the shoulder-joint. Of these, ligature of the subclavian

must be rarely contemplated. It is in itself a very fatal operation. It would be very likely followed by gangrene of the extremity, because the anastomosing vessels about the shoulder, upon which the limb must depend for its supply of blood, would remain compressed by the extensive coagula. Also diffuse suppuration and sloughing of the space might occur, and this too would involve the shoulder-joint, which had been opened by the dislocation of the head of the humerus.

Amputation at the shoulder-joint, a comparatively successful operation, under ordinary circumstances, would naturally be very unacceptable to a patient, but would probably commend itself to the surgeon in the old subject. By this proceeding a cavity which must necessarily suppurate, would be reduced to a minimum, and there would be no joint left to be exposed to all the dangers of inflammatory disorganization. But the shock of the operation, added to the existing condition, might prove fatal. I have collected nine cases of ligature of the axillary artery in similar circumstances, of which eight died and one recovered.

To lay open the swelling, and to secure the wounded vessel with a double ligature, is in accordance with the principle of the surgery of arteries, and in the comparatively young subject should certainly be the means resorted to.* In the old,

* Callender, "Barth. Hosp. Reps." vol. ii.; also J. Lister, *Med. Times*, Feb. 1st, 1873.

the extensive suppurating cavity that must result would probably kill.

[It will be convenient, in connection with this case, just to mention another instance of hæmorrhage from the axilla.

Case 23. *Cancer of Axilla; Hæmorrhage; Ligature of Axillary Artery.*—T. M——, aged thirty, was admitted into the London Hospital, under the care of Mr. Critchett, Dr. Bathurst Woodman being house-surgeon, with some swelling of the left axilla, and an ulcer of the size of half-a-crown in the floor of the space near the anterior fold. The man looked pale, and said that he had lost blood from the sore.

On December 3rd, 1861, Mr. Maunder saw the case, having been summoned on account of recurrence of hæmorrhage, and found the patient exceedingly prostrate and exsanguine. The history was obscure, the patient being almost too exhausted to reply to questions put to him. From what could be gathered the disease had existed some twelve months; a lump in the armpit having been discovered accidentally one morning (which the patient said was not there on the previous evening); this lump had increased in size, becoming harder, until about a month ago when the skin broke. On the 29th November bleeding to a great extent occurred at his lodging, but ceased spontaneously; it returned twice during the night of December 2nd, but was controlled by plugging with cotton wool and a solution of perchloride of iron. As to the precise nature of the

malady, the man was too weak (and no time could be allowed for a close examination) to determine. It might be either malignant disease involving a large artery, or a ruptured aneurismal sac. A consultation was held with Mr. Curling and Mr. Critchett, and it was deemed right to endeavour to secure the bleeding vessel, though the man should die on the operating table, rather than, unattempted, to allow the patient to succumb from hæmorrhage in his bed. The anterior wall of the axilla was accordingly laid open up to the clavicle, disclosing a mass of malignant disease, softening and involving the contents of the cavity. The bleeding point could not be detected, but after scraping away the cancerous substance the axillary artery was found, and a ligature was applied at the highest point practicable. This controlled the hæmorrhage. The man died the same afternoon.

Post-mortem examination.—Besides involving the upper part of the pectoralis major and minor muscles, the disease had destroyed the posterior half of the circumference of the axillary artery in the middle of its course to the extent of half an inch. Opposite to this, a cavity, large enough to contain a walnut, stained with blood, and partly filled with coagula, but with a hole in its wall, existed, and was, doubtless, the source of fatal hæmorrhage. The axillary vein was compressed, and partly obstructed by clot. The ligature constricted the

vessel about three-quarters of an inch above the wound in it.

The operation was necessarily undertaken in utter ignorance of the nature of the case. As it was, the bleeding point was not found, and in all probability had the patient survived three or four days, hæmorrhage would have occurred from the distal side of the wound, which, at the post-mortem examination, proved to be in the axillary artery.]

In the absence of a wound, the artery may be thus reached:—

LIGATURE OF THE AXILLARY ARTERY.

Anatomical Relations.—This vessel, the continuation of the subclavian artery, extends from the lower border of the first rib to the lower border of the tendons of the latissimus dorsi and teres major muscles. It may be ligatured at any point with more or less difficulty, but opposite the lower border of the pectoralis major muscle with comparative ease. In the upper two-thirds of its course this artery is covered in by one or both pectoral muscles.

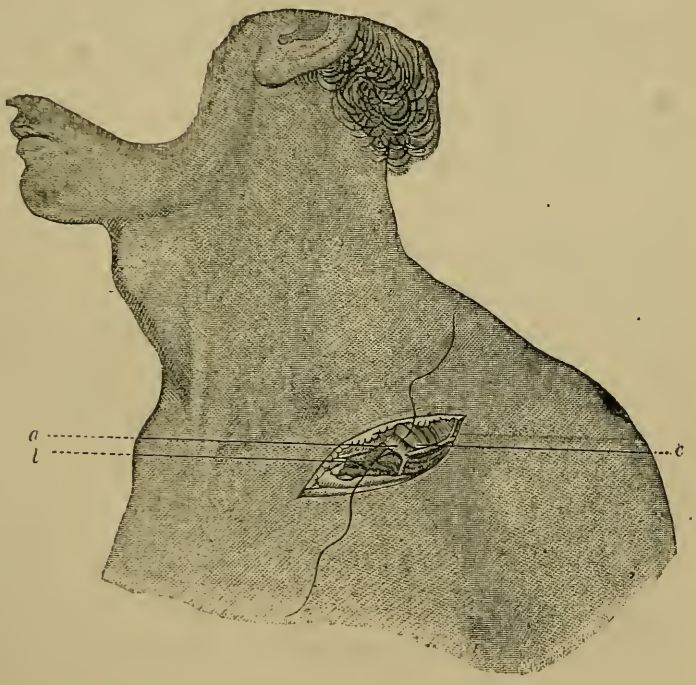
In the upper third, it will be found between the clavicle and upper margin of the pectoralis minor muscle, having the brachial plexus above and external to it, the axillary vein below and internal to it, and, when distended with blood, slightly overlapping the artery.

OPERATION.

Various incisions have been proposed to lay bare the artery while it is behind the pectoral muscles, and of these one parallel to the clavicle is as convenient as any.

Make an incision at least three inches in length, just below and parallel to the middle of the clavicle,

FIG. 8.



dividing the integuments, fibres of the pectoralis major muscle, a layer of fascia between the upper border of the pectoralis minor muscle and the clavicle, on a director; and carefully avoiding the

trunk of the thoracica-acromialis artery coming forward over the upper margin of the pectoralis minor muscle, and the cephalic vein crossing the axillary artery from without inwards to join the axillary vein, open the sheath of the vessels prolonged from the costo-coracoid membrane, and pass the aneurism needle from within, outwards and upwards, avoiding the vein on the inside and the nerves on the outside. Fig. 8 shows the artery (*a*) with the ligature *in situ*, the vein (*b*) below and internal to the artery, and the brachial plexus (*c*), which, from a surgical point of view, may be considered as one cord in this position, external to and above the vessel. Tie all vessels which bleed and impede the progress of the operation.

Another mode consists in making an incision from the clavicle downwards, corresponding to the interval between the pectoralis major and deltoid muscles. These muscles separated, the pectoralis minor, passing upwards and outwards, will come into view, and may be divided on a director introduced above it. The sheath opened, the artery will be found surrounded by the nerves of the brachial plexus, the two heads of the median becoming blended in front of it, while the vein lies to the inner side of the artery. In consequence of the proximity of the nerves to the artery, the vessel cannot be readily ligatured in this position. Prior to making the first incision, the course of the cephalic vein, lying in the groove between the pectoralis major and deltoid

muscles, should be determined by making pressure near the clavicle, so as to obstruct the flow of blood through it.

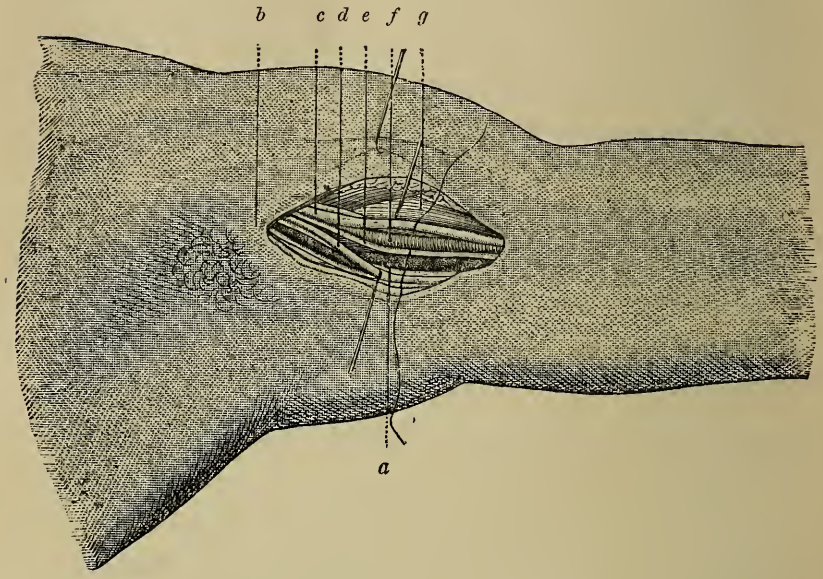
Ligature of the Lower Third.—Below the pectoralis minor muscle the axillary artery may be readily exposed, while lying posteriorly on the tendons of the latissimus dorsi and teres major muscles, and externally on the coraco-brachialis muscle. It is covered in by skin, superficial, and deep fasciæ; the median nerve is external to it, the internal cutaneous nerve is in front of it, and the axillary vein is internal to it.

To expose the axillary artery in its lower third, remove the arm from the side, and place it at nearly a right angle to the body; feel for the round bundle of the coraco-brachialis muscle lying along the inner side of the arm, and immediately behind the anterior fold of the axilla. Now divide the space between the anterior and posterior folds of the axilla into thirds, the point of junction between the anterior and middle thirds will mark the position of the artery.

Make an incision two and a-half inches in length, parallel to the course of the artery, and at a distance from the anterior fold, as described above, dividing the integument only; complete the remaining necessary incisions on a director, lest the vein be wounded; and the sheath being opened, pass the aneurism needle from within outward. Fig. 9 shows the position of the patient's arm and the required incision, also the axillary vein (*a*), the arm-pit (*b*), the median

nerve (*c*), the ulnar nerve (*d*) held aside, the internal cutaneous nerve (*e*), the axillary artery with

Fig. 9.



the ligature in position (*f*), the coraco-brachialis muscle (*g*).

The point of selection for ligature of the axillary artery will be its lower third, because it is here comparatively superficial.

The fourth case of traumatic aneurism—(No. 8. *Wound of Popliteal Vessels*) — is that of J. M——, aged sixteen, whom I saw in December, 1862, with the late Mr. Leach, of the Borough, on the seventh day subsequent to the accident. The lad had been stabbed on the inner side of the thigh at the junction of its middle and lower thirds. Copious bleeding was arrested by a

bystander, and a compress and bandage prevented further hæmorrhage. I found an extensive pulsating swelling, which was on the increase, about the seat of injury, and the leg was very œdematous. The wound, about half an inch in length, was plugged by a portion of cellular tissue. The dorsalis pedis artery could be felt pulsating. In consultation with Mr. Hutchinson, it was agreed that the cause of the pulsating tumour should be sought for at the wound. The swelling was laid open upwards and downwards, and the forefinger of the left hand, quickly inserted, followed the original track of the knife and entered a wounded vessel, the tip of the finger being then bathed in warmer blood. With the greatest difficulty, by reason of the depth of the wound and the constant welling up of blood whenever the finger was moved in the least degree, a ligature was applied to the popliteal artery above and below the wound in it. The finger was now removed, when quite unexpectedly dark blood gushed up; and in the belief that the main vein also was wounded, amputation was at once performed at the seat of injury. The popliteal artery and vein proved to be both wounded; the former to the extent of half its circumference, the latter almost severed. A very large quantity of blood was lost during the attempt to ligature the artery. The patient scarcely rallied, but died on the sixth day.

The increase in size of the pulsating swelling, the œdema of the leg, and the fact that the wound

in the thigh could not be said to be closed by adhesion, brought the case practically to one of wounded artery rather than of aneurism, and was, therefore, to be treated by ligature at the seat of injury. The extravasation was chiefly fluid, and comparatively limited, and that must be explained on the supposition that the blood which escaped into the thigh at each systole re-entered the vessels in great measure at each diastole, and also possibly by an alternating transference of blood from one vessel to another. The vein also being wounded was a very serious complication, and believing that in the lower extremity obstruction of both of the main vessels would lead necessarily to gangrene of the limb, amputation was performed in preference to either the application of a ligature to the vein, or of plugging to prevent hæmorrhage from it. This belief on my part originated in a dictum of Guthrie,* who says: "I have had many opportunities of seeing the vein and artery of a limb divided by a wound or included in a ligature; but I have rarely seen one in which mortification did not ensue; and I am disposed to consider it as a general rule, liable to an occasional exception, that when the femoral artery and vein are divided or included in a ligature, the limb will be lost by gangrene." Also, when a student, I remember seeing a case of gunshot wound of the thigh, leading to obstruction of both femoral vessels,

* G. J. Guthrie, "On the Arteries," 1830, p. 128; also, Syme, "Principles of Surgery," p. 99.

followed by gangrene, under the care of Mr. Hilton, in Guy's. On the other hand, in a very similar case to mine, Mr. Holthouse, having tied the femoral artery, then plugged the wound and prevented further venous bleeding. The man recovered after sloughing of a small portion of skin on the outside of the foot.* In the future, under similar circumstances, and in the young subject, I should be disposed to secure both the vessels and to await the consequences.

LIGATURE OF THE POPLITEAL ARTERY.

[This vessel traverses the centre of the popliteal space vertically. In front of it are the femur, with more or less fat intervening, the posterior ligament of the knee-joint, and the popliteus muscle; behind the vessel, and external to it, are the popliteal vein, which in this region is joined by the short saphena vein from below, and the internal popliteal nerve superficial to and also external to, the vein; laterally, the artery is bounded by the various muscles, inclosing the space. The deep fascia, a prolongation of the fascia lata, strengthened by additional transverse fibrous bands, binds together all the above organs, as well as some lymphatic glands which lie about the artery. In the lower half of this space branches of these popliteal vessels and internal popliteal nerve form a network about the artery, and therefore

* "Syst. Surg.," 2nd edition, vol. i. p. 740.

induce the surgeon to select the upper part of the vessel as the seat of ligature.

OPERATION.

The subject being prone and the leg extended, make a vertical incision from three to four inches in length along the centre of the popliteal space, two-thirds of the incision being above, and one-third below the line of the articulation between the femur and tibia. Divide the integuments cautiously, so as not to wound the external saphena vein, slit up the deep fascia on a director, and then seek the internal popliteal nerve, the most superficial of the three organs above mentioned; flex the leg partially upon the thigh, so as to relax the parts, and let an assistant hold aside the above nerve; now seek the vein, which is still deeper than, and internal to, the nerve, and having found this vessel, seek the artery still deeper than, and internal to, the vein, and pass the aneurism needle from without to within. The various organs occupying this space are so bound together by the deep fascia, and the space thereby rendered so deep, that the artery cannot be readily reached unless a free incision be made.]

In describing the operations performed in some of the above cases, in order to secure a wounded vessel, I feel that I have failed in great measure to convey to the mind of the listener, who has never witnessed such, an adequate idea of their

formidable nature. The difficulties of a case can perhaps be somewhat appreciated when it is remembered that the injured vessel is to be secured at the wound, and not on the cardiac side at a distance from it. This vessel may be far from the surface, its exact position unknown, in the neighbourhood of other and important vessels and of other important structures, at the bottom of a large irregular cavity, full of old and recent bloodclot, and with walls stained and friable and sodden with blood. Both direct and indirect control of the vessel may be impossible, and, therefore, at the risk of great loss of blood, at a time when one gush may kill the patient, the original wound must be enlarged not only with rapidity that the finger of the surgeon may compress the bleeding point, but with precision, having due regard to the vessels and nerves of the region, and severing without hesitation fasciæ and muscles which interfere with his one great object.

A wound of the accompanying vein doubles the difficulty.

Another class of cases is that in which a wound having been inflicted, and hæmorrhage arrested at the time, is followed after a shorter or longer interval by recurring bleeding. A favourite seat for these is the neighbourhood of the wrist and the hand. In primary hæmorrhages from wounds of this region, every reasonable attempt should be made to secure the vessel at the bleeding point, as already stated; but the surgeon will frequently not be

brought in contact with his patient until various means have been resorted to to arrest hæmorrhage, and have failed. By this time important changes in the shape of œdema, suppuration, sanguineous infiltration, and threatening gangrene may have occurred. The following illustrate these observations:

Case 15. *Wound of Hand; Hœmorrhage.*—H. G——, thirty-eight years of age, on February 8th, 1865, was wounded with a chisel, which penetrated the hand in the first interosseous space. Blood spurted freely, but was arrested by closing the wound by suture, compress and bandage. Bleeding recurred several times. Various methods of treatment were resorted to: plugging with perchloride of iron; compression of the radial and ulnar arteries; ice; flexion of the forearm on the arm. February 17th.—Parts look gangrenous, and hæmorrhage returned. The extremity is œdematous, almost up to the shoulder. Mr. Maunder now saw the case and ligatured the brachial artery, just below the axilla. Quickly following delegation of the artery, sloughing ceased and healthy action set in. Many months subsequently the author saw this patient at Loughton, and the hand was comparatively useless. He is here to-night, and is an example of overdone compression, etc. I have particulars of four other cases of ligature of brachial for wound of palm; three recovered and one failed. In one of the cases that recovered, a second large vessel (high bifurcation) had to be secured.

Case 14. *Wound of Wrist; Recurring Hæmorrhage* (Reported by Mr. Stanley Gill, house-surgeon).—Thomas C——, aged thirty-one, was admitted into the London Hospital on October 10th, 1871. He had fallen through a pane of glass and wounded his right wrist. There was a great deal of hæmorrhage, but the bleeding vessel could not be secured at the wrist. The patient was put to bed and a pad of lint was firmly bandaged to the wound, and a tourniquet ordered to be kept at his bedside. This man had several attacks of hæmorrhage, and as many attempts were made by the house-surgeon to secure the vessel at the seat of wound, but without avail. Flexion of the forearm also failed. These bleedings occurred in the intervals of the surgeon's visits. On November 16th, twelve days having elapsed since the last bleeding, hæmorrhage set in a short time before Mr. Maunder's visit, and on his arrival he ligatured the brachial artery in the middle of the arm. By this time, five weeks subsequent to the injury, the wrist was swollen, and the parts a good deal infiltrated by inflammatory effusion. No bleeding occurred after the operation, and the wrist wound healed in due time, but the operation wound remained open a long while. A catgut ligature was used. The man remained weak for many weeks, and only left the hospital on February 17th, 1872.

Case 19. *Wound at Bend of Elbow; Recurring Hæmorrhage; Ligature of Ulnar Artery* (Reported by Mr. C. L. Drew).—B. G——, thirty years of age,

was admitted on May 21st, 1872. He had just sustained a wound by broken glass across the bend of the elbow. There was considerable bleeding, and one small vessel was tied by the house-surgeon, Mr. Stanley A. Gill, of Torquay.

May 23rd.—He became an out-patient.

May 26th.—Free bleeding occurred, and he returned to the hospital and was re-admitted, looking very anæmic. Compresses about the wound, and a bandage to the arm were re-employed.

May 27th.—Bled again this morning. At 2 p.m., on "going round," Mr. Maunder saw the case, and determined to open the wound in order to secure the wounded vessel. The ulnar artery was found divided close to its origin, and both ends were secured. Arterial blood flowed from both ends. The patient was very exsanguine, and had evidently lost a great deal of blood. The limb was secured to a splint with a flannel bandage. Ordered milk, and beef tea, and brandy.

July 5th.—No further trouble arose, and he was discharged cured to-day.

Other cases of hæmorrhage associated with suppuration and sloughing, but not the result of wound, are as follows :—

Case 17. *Suppuration ; Hæmorrhage.*—W. D——, aged twenty-eight, had sustained a severe blow on his wrist. Suppuration, sloughing, and disorganization of carpal joints followed. On the morning of March 8th, the patient bled to a large extent,

and on the 11th a pulsating swelling was discovered at the back of the first interosseous space. Suppuration was now profuse. Mr. Maunder introduced his finger into the swelling, and blood rapidly followed its withdrawal. Amputation was advised, but refused; and as an alternative the brachial artery, rather than the bleeding vessel,* was ligatured. Hæmorrhage did not return, and the man died on the 21st, with symptoms of pyæmia.

Examination of the Ligatured Artery.—No ligature (antiseptic catgut) could be found. The inner coats of the vessel had been cut through, and its channel was obstructed by adhesion. A quarter of an inch *above* the seat of ligature, a branch was given off, and there was no clot; three-quarters of an inch *below* the seat of ligature a branch also came off, and a small coagulum existed between them.

Case 20, 21. *Two Arteries tied: Suppuration; Hæmorrhage.*—Mrs. ——, aged forty-nine, admitted November, 1868. The subcutaneous tissues of the foot were in a state of suppuration and sloughing, and several ulcers existed in the skin covering this. She was extremely exhausted, having been ill-fed of late. On the 14th I was summoned at midnight in consequence of hæmorrhage, for the second time that day. The patient was now excessively feeble. It was impossible to say whence the bleeding came, and to search for its source here and there in

* Case by Mr. Nunn, *Med. Times*, March 22nd, 1873.

sloughy tissues was out of the question, because, could it have been discovered and secured by ligature, the probability is that the thread would have been rapidly cast off, and hæmorrhage would have recurred. Amputation was the remedy both for the arrest of bleeding and the removal of a hurtful member, diseased beyond repair; but this operation could not be entertained in the exhausted condition of the patient. It was necessary to do something to prevent recurrence of hæmorrhage while the patient gained strength, and then an opportunity for amputation might present itself. I would not ligature the superficial-femoral artery, because, with a very weak circulation, gangrene of the whole limb would probably immediately set in, attended by shock and rapid death; or, if this catastrophe did not happen, hæmorrhage might again recur with reaction. I attempted a plan intermediate between ligature and doing nothing locally. I endeavoured, with the longest acupressure needle at hand, to compress the femoral artery against the femur in the middle of the thigh, but, as it turned out, the needle was soft and bent around the bone, and was useless. I thought that in this region I could compress the femoral artery so as, at any rate, to diminish the flow of blood through it, and yet not obstruct the vein; and so when reaction came on, any clot formed at the seat of hæmorrhage might withstand the impact of blood. The attempt failed, as I have stated, and I contented myself with adjusting a

tourniquet, in case of need. Next day the patient was still extremely weak. On the following day, the 16th, hæmorrhage recurred, and I then determined to tie the anterior and posterior tibial arteries as near the foot as possible, in order to gain time, and amputate a few days hence. These vessels were ligatured about the middle of the leg. Hæmorrhage did not recur. The patient died of exhaustion on the following day.

This case and the preceding are examples of hæmorrhage as the result of sloughing, and, occurring as it did in structures so disorganized as to be beyond repair, the remedy for the bleeding and the safety of the patient rested in amputation if in anything. In both it was impracticable: by the one refused, in the other inadmissible at the time.

LIGATURE OF THE POSTERIOR TIBIAL ARTERY.

This vessel extends along the centre of the back of the leg between the two layers of muscles, occupying that region from the termination of the popliteal artery to a mid-point between the internal malleolus and the insertion of the tendo-achillis.

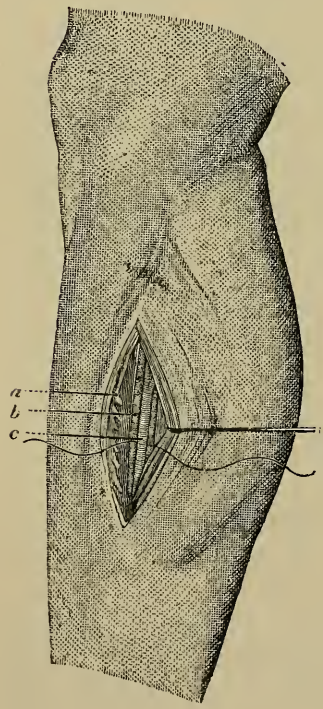
The artery is attended by venæ comites and by the posterior tibial nerve, which in the upper fourth is internal to the artery, but in the lower three-fourths is external to that vessel.

OPERATION.

This vessel may be ligatured at any point of its course, and with comparative ease in the lower third of the leg, where it is not covered by muscle.

Ligature of the Middle Third of the Leg.—The surgeon should first ascertain the position of the internal saphena vein ascending along the inner side of the leg, and, having done so, make an incision (Fig. 10) three or four inches in length, parallel to the inner margin of the tibia, and a finger's breadth behind it, dividing the integument and deep fascia. He will now probably see the free margin of the gastrocnemius muscle lying upon the soleus, which former should be held aside while the fibres of the latter muscle (*a*) are cautiously divided to a similar extent as the integument, until a whitish fibrous membrane be reached. (I beg to draw especial attention to this "whitish fibrous membrane," because it is the tendinous origin of

Fig. 10.



the soleus muscle from the tibia, and not, as I have known students suppose, the aponeurosis separating the superficial from the deeper layer of the muscles.) Slit up this tibial origin of the soleus on a director, and seek for the pearly-looking intermuscular septum, the transverse fibres of which are sometimes distinctly seen, separating the two layers of muscles, and binding the artery upon the tibialis posticus muscle (or rather upon the posterior tibial aponeurosis). Divide this inter-muscular septum on a director also, and seek the artery (*c*) external to the outer border of the tibia, attended by venæ comites (*b*) and the posterior tibial nerve, the latter to its outer side. Pass the aneurism needle from without inwards.

Caution.—Some authorities advise that the soleus muscle should be detached close to the tibia, but it should be remembered that the flexor longus digitorum muscle also arises from the tibia, just external to the linear origin of the soleus, and would almost surely be detached with the soleus; and if so, the operator would get into the substance of the flexor muscle, and anterior to the artery instead of being behind it, as is desired. Any muscular branch of artery which bleeds should be immediately ligatured or twisted.

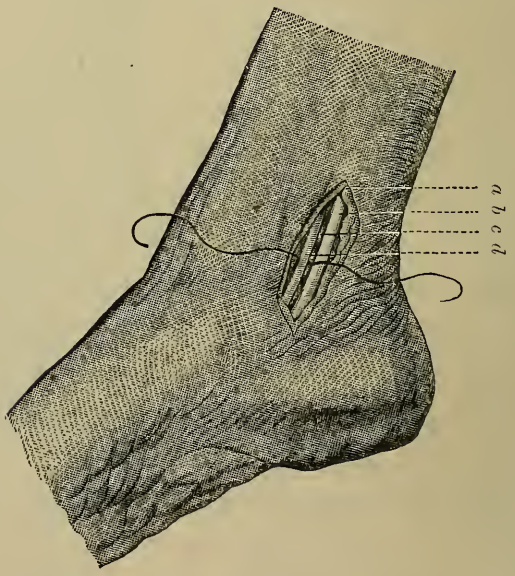
Another method consists in making a vertical incision along the middle of the back of the leg through the superficial muscles. This is not so convenient as the former, because the artery is

further from the surface, and more injury is inflicted on the various organs interested.

Ligature at the Lower Third of the Leg.—In this position the vessel lies about midway between the tendo-achillis and the inner border of the tibia, is attended by venæ comites and by the posterior tibial nerve lying to its outer side; internal to the artery are the tendons of the tibialis posticus and flexor longus digitorum muscles.

The vessel may be readily reached in this locality by an incision (Fig. 11) two inches in length,

Fig. 11.



parallel to the inner edge of the tibia, and a finger's breadth posterior to it. By this method the artery will be ligatured about one inch above the inner

malleolus, and the parts to be divided are the integuments and the deep fascia (*a*), on a director.

Some fat will now be seen, and in it the sheath with the artery (*d*) and venæ comites (*c*). The posterior tibial nerve (*b*) is external to the artery. When performing this operation, the surgeon should be careful not to open the sheath of the tendons lying on the posterior surface of the tibia. Also, both in this and the former operation, the limb is resting on its outer surface, and the incision in both cases, although parallel to the artery, is not immediately over it, but rather on a plane posterior to the vessel. The artery in both instances must, therefore, be looked for anterior to the direction given to the scalpel in effecting the integumental incision.

LIGATURE OF THE ANTERIOR TIBIAL ARTERY.

On the surface, a line drawn from the inner side of the head of the fibula to a mid-point in front, between the internal and external malleoli, will mark the course of the artery. In the upper three-fourths of the leg the artery rests upon the interosseous membrane, in the lower fourth upon the tibia. It is more superficial below than above, in consequence of the diminution of the size of the tibia and muscles. On the outer side the vessel is bounded in the upper third by the extensor longus digitorum muscles, in the middle third by the extensor pro-

prius pollicis, in the lower third by the extensor longus digitorum.

On the inner side the artery is bounded throughout by the tibialis anticus muscle, the outer border of which marks the course of the artery, and can be felt with tolerable facility when the muscle is in action. In front, in the upper two-thirds, the artery is concealed by the apposition of muscles above mentioned, deep fascia, and integument; in the lower third, besides integument and deep fascia, the vessel is crossed from without inwards by the extensor proprius pollicis muscle. Venæ comites accompany the artery; also the anterior tibial nerve, with uncertain position.

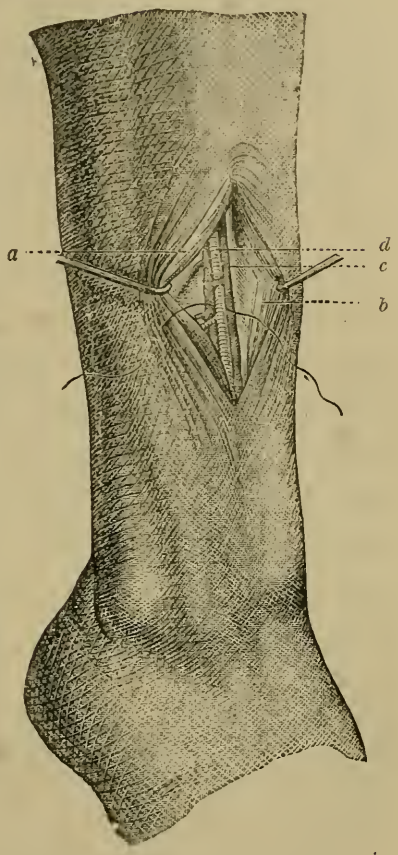
OPERATION.

This vessel may be ligatured at any point, but with more ease towards the lower than upper extremity of the leg. In the upper third the vessel is very deeply seated; and as the muscles arise partly from the deep fascia covering them, the muscular space between the tibialis anticus on the inside and the extensor longus digitorum on the outside, cannot be readily found, although sometimes a whitish line will mark the position of the inter-muscular septum.

Ligature in the Middle Third of the Leg.—Make an incision (Fig. 12) three inches or more in length, over and parallel to the course of the artery, dividing

the integument only. Seek now a white line in the deep fascia, marking the septum between the tibialis anticus on the inside, and the extensor longus digitorum on the outside.

Fig. 12.



Divide this white line of deep fascia longitudinally, and nick it transversely also at one or two points, if it prevent ready separation of the edges of the wound.

Flex the foot upon the leg so as to relax muscles, and (*caution*) not forgetting that in the middle third of the leg the extensor proprius pollicis muscle lies to the outer side of the artery, and concealed from view by the apposition of the tibialis anticus and extensor longus digitorum, separate the edges of the wound by drawing the tibialis anticus muscle (*b*) to the inside, and the extensor proprius and extensor longus digitorum (*a*) to the outside. The nerve will probably be seen first, somewhat anterior to the artery (*d*), the latter being attended by

venæ comites (*c*). Pass the ligature according to rule.

The anterior and posterior tibial arteries may be readily compressed just above the ankle joint against the tibia during the performance of operations on the foot.

[*Abscision of Tonsil; Hæmorrhage.*—As an illustration of the value of *indirect* compression for hæmorrhage, I may mention a case of very severe bleeding after abscision of a tonsil, which I saw some years ago with Messrs. Mundie and Daly, of Dalston. Various remedies had been used, and I found the patient blanched and her mouth maintained wide open with a wine-cork which had been inserted between the teeth to allow more air to pass across the wound, and since which bleeding had ceased. Such being the case, it was agreed that nothing further should be done unless the bleeding returned. It did not do so. In answer to my inquiry about this patient, Dr. Daly replies on October 30th, 1874:

"You are quite correct about the tonsil case; Mundie and I removed the tonsil on the Wednesday, and the hæmorrhage continued all that night and all Thursday, although we used any quantity of ice, liq. ferri perchlor., matico and acid gallic internally. It ceased on Thursday evening, but returned with increased profusion and alarming symptoms on Friday, when we used the cork, and it immediately ceased and *never returned.*

"You saw the case on Saturday, and recommended the cork to be kept in, which was done for four days longer. The cork used was a large wine cork."

My theory was that in the very feeble condition of the patient the angle of the jaw exercised compression on the main artery so as to diminish the flow of blood through it, and prevent the dislodgment of coagulum from the bleeding vessel.

Also, another instance: — *Fractured Jaw; Hæmorrhage.*—W. C——, twenty-six years of age, sustained a fracture through the left angle of the lower jaw, on September 10th, 1867, from a blow with the fist. On the following day he came to the hospital bleeding freely from the mouth. He was admitted, and a compress of lint having been placed between the jaws as far back as possible, the lower was firmly fixed by a bandage against the upper. Free sanguineous oozing soon returned, and, when I arrived, continued. On examination the blood seemed to flow from a fissure in the gum, occupying the site of the last molar tooth. The blood flowed so freely, unless controlled by compression of the left common carotid artery, that some radical measure appeared necessary if the hæmorrhage continued. I conjectured that the blood flowed from a lacerated inferior dental artery, and finding that pressure on the carotid was efficient, three or four gentlemen, students of the hospital, volunteered to exercise continuous digital compression.

The patient was placed on a sofa in a semi-recum-

bent posture, and digital compression was exercised during a period of two and a-half hours, when it was discontinued. He remained on the sofa, dressed, during the night, and after a period of altogether twenty hours repose, was allowed to go to his ward.

Hæmorrhage never recurred, and the patient was soon convalescent.]

Another instance—Case 23.* *Hospital Gangrene; Hæmorrhage*—that of a female, aged sixty-six, the subject of a compound fracture of the leg, attacked by hospital gangrene, and followed by hæmorrhage, was advised to submit to amputation, with a view to the removal both of the damaged limb, and to prevent further bleeding. She refused, and I was obliged to be content with tying the anterior tibial artery in healthy structures above the wound. Bleeding did not recur, and gangrene ceased.

Again, Case 8. *Contused Extremity; Suppuration; Hæmorrhage.*—H. P——, aged forty-seven, sustained a severe squeeze of the knee. Profuse suppuration up and down the limb, and disorganization of the knee-joint followed. About six weeks after the accident, severe hæmorrhage occurred twice through sinuses in the popliteal space; the second time while I was in the hospital. I tied the superficial femoral artery with the hope that the man might rally. Bleeding did not recur.

At a post-mortem examination the source of

* See "Table of Arteries," p. 3, and *Lancet*, January 9th, 1875; also "Lond. Hosp. Reps.," vol. i. pp. 106, 134.

hæmorrhage could not be found, and as, when the man was alive, I also did not expect to find it, I did not in this instance attempt to do so.

The artery was ligatured on the principle that no one can say with certainty that a patient has or has not just enough blood left in his system to support life; and, therefore, it is right to give the sufferer a chance of prolonged existence by an operation comparatively painless, bloodless, and capable of being quickly executed.

Again, Case 13. *Sloughing Palm; Hæmorrhage.*—B. A——, sixty-six years of age, ran a splinter of wood into his thumb. The accident was followed by suppuration and sloughing of the soft parts, and destruction of the phalanges and associated joints. The outer half of the palm was also undermined. The thumb had just been amputated by a colleague, in whose absence I was called on the occasion of a fourth bleeding. I tied the brachial artery. Hæmorrhage did not recur, but the patient died exhausted four days later. Three days after operation, pulsation had returned to the radial artery at the wrist. In this and the previous case it would have been useless to attempt to secure the bleeding vessel among tissues so disorganized. In the former it certainly would not have been found, and in the latter the ligature would soon have been cast off with a repetition of bleeding.

Case 25. *Malignant Disease of Tongue; Hæmor-*

rhage; Ligature of Right Lingual Artery(?).—Dr. Floyer's report is:—"Mrs. C——, a rather tall, large-framed woman, dark hair, and swarthy complexion, about fifty years of age, in the spring of 1869, came under my care for an ulcer on the right side of the tongue, opposite the second molar tooth. It was irregular, excavated, and rather hard, and everted at the edges. She being of a costive habit of body, I gave her some aperient medicine, and applied nitrate of silver on several occasions; advised, the tooth being filed and ultimately extracted. No improvement followed—the ulceration extended, the patient became weaker, swallowing more difficult; repeated hæmorrhages ensued. The friends wishing all to be done that was possible, Mr. Maunder was requested to see her, and on December 29th, 1869, he ligatured the right lingual artery, which was so nearly obliterated by the extension of the disease down the neck and root of the tongue, that it was scarcely recognizable. In a very short time hæmorrhage recurred, deglutition became almost impossible, and she finally sank and died on the 17th of March, 1870."

Adelmann and Demarquay record about fifteen cases in which the lingual was tied for hæmorrhage from cancer, or preliminary to operating on the tongue. Liston, Moore, Heath, and H. Morris have also tied it (the latter three times). The total number of cases is about twenty-two. In many of

them hæmorrhage recurred a few days after the application of the ligature.

LIGATURE OF THE LINGUAL ARTERY.

Course and Anatomical Relations.—This vessel usually arises from the external carotid just below the greater cornu of the hyoid bone, and passing inwards, forwards, and upwards, gets above the hyoid bone, and under cover of the hyo-glossus muscle.

OPERATION.

To expose the vessel, turn the face to the opposite side, and make an incision one and a-half inches in length, just above the greater cornu of the hyoid bone and parallel to it, the centre of the incision to correspond with the point of the greater cornu, which should be made prominent by pressing upon the opposite side of the bone. Divide skin, superficial fascia and platysma, and deep fascia. The edges of the wound being separated, look for the posterior belly of the digastric muscle, passing downwards and forwards; and, just below this, for the white cord of the hypoglossal nerve, also passing forwards. Feel for the greater cornu of the hyoid bone, and observe the upward course of the fibres of the hyo-glossus muscle, and if its free border be visible, the artery will be found immediately behind it; should the free border not be visible, a few of its fibres

divided transversally, will allow the artery to be seen and ligatured. The facial vein, if seen, should be held on one side.

Another Mode.—This vessel may also be ligatured in front of the posterior belly of the digastric muscle by an incision begun nearer the middle line of the neck, but the submaxillary gland must be disturbed in order to reach it in this position, where it lies in a triangular space, bounded by the two bellies of the digastric muscle and the hypoglossal nerve above, forming the base of the triangle. The hypoglossal nerve is superficial to the hyo-glossus muscle, but the lingual artery is beneath this muscle.

The next are examples of hæmorrhage from the base of the skull.

Case 26. *Gunshot Wound; Hæmorrhage; Ligature of Common Carotid.*—In September, 1855, I volunteered to do duty in the Crimea, from the Civil Hospital at Renkioi on the Dardanelles. Having reached "the front" with two colleagues, Drs. G. Buchanan and J. Cowan, of Glasgow, who had a similar object in view, I was put in charge of two huts, each containing about a dozen wounded Russians. On inspecting my patients I found one about twenty years of age, wounded in the attack on the Redan some days previously, to be the subject of secondary hæmorrhage. A ball had entered the pterygo-maxillary region of the left side, between the mastoid process and the ramus of the jaw,

and had made its exit at the orbit, destroying the globe. From these points blood trickled, and the patient was greatly exhausted.

A consultation was held, and it was agreed that the left common carotid artery should be ligatured. Both the cheek and side of the neck were greatly swollen, partly by the presence of extravasated blood and partly by inflammatory œdema. The effect of this was to obscure altogether the anatomical landmarks which usually guide one to the artery, and I presently found myself, after cutting through sodden, stained, and ill-recognizable tissues, in the middle of the sterno-mastoid muscle.* But having got so far, I persevered and ligatured the vessel in the usual manner.

This was my "maiden" operation, and it was not attended by a happy issue, notwithstanding, as can be imagined, all my efforts to that end. The patient did not thoroughly rally, but died exhausted from loss of blood. Hæmorrhage ceased on the application of the ligature.

My researches furnish me with the particulars of 101 cases in which the common carotid was tied for wound and traumatic aneurism. Of these thirty-four recovered and sixty-seven died. It should be borne in mind that eighty-six of these were for gunshot injury, of which sixty-four died and twenty-two recovered. Of the cases occurring in civil practice, twelve recovered and three died.

* See Maunder's "Oper. Surg.," 2nd edit. p. 54.

Case 27. *Phosphorous Necrosis; Hæmorrhage; Ligature of Common Carotid; Recovery.*—A male, aged twenty-four, had been submitted by Mr. John Adams to the removal of the whole lower jaw, which had become necrosed from exposure to the fumes of phosphorus. At the time of operation the sequestrum was incased in new bone, and required the use of some force in order to dislodge and remove it in two chief portions, after the section of the symphysis, with a chisel and mallet. On the 13th of March, 1861, the right half only of the jaw was taken away; on the 27th of the same month the remaining portion was extracted. The case progressed favourably until the 30th, when, at eleven a.m., severe hæmorrhage occurred from the mouth, apparently from the right side; this was checked by pressure with the finger and a sponge compress applied inside the cheek, and by the use of ice outside; at three p.m. the bleeding recurred, and was controlled by the finger and sponge retained in the mouth until I reached the hospital. I found the patient blanched by loss of blood, with an almost imperceptible pulse, and the least relaxation of the pressure of the finger was attended by bleeding. The pressure was directed towards the pterygoid region.

The patient being already much exhausted, with a direct evidence of a further tendency to hæmorrhage, I deemed it to be unadvisable to attempt to find the bleeding point in the cavity of the mouth, but preferred placing a ligature upon the common carotid

artery. The vessel was ligatured in the antero-superior triangle of the neck, one small superficial vessel also requiring a ligature; neither nerves nor the internal jugular vein was seen during the operation. On the following day the patient had rallied somewhat. On the 19th April, the case having been carefully watched by the house-surgeon, Dr. Edmund Gwynn, of Hampstead, and having progressed favourably throughout, the ligature on the main vessel came away. The wound was healed, excepting at the site of the ligature.

During some weeks after the operation, the patient complained occasionally of pain on the right side of the head, of tremulous action of the heart, of general debility, and profuse perspirations—all of which symptoms gradually subsided under the use of quinine, steel, and cod-liver oil.

I saw him some months after the operation, when he appeared to be in good health, and had a firm but narrow bony substitute for his jaw.

In both these examples hæmorrhage was probably a consequence of ulceration or sloughing following a bruised wound. In an accessible region to find a bleeding vessel under such circumstances would be difficult, perhaps impossible, and at any rate likely to be quickly followed by separation of the ligature and renewed bleeding. Being, however, doubtful of the precise seat of the hæmorrhage, I deemed it more prudent to place a ligature upon the main artery of the region rather than to attempt any

operation which might be equally, or even more severe, and probably unsuccessful. The operation performed was at variance with the sound principles of surgery, but in these instances (hæmorrhage from a doubtful source in an important region) an exceptional method was unavoidable and therefore admissible.

Although in no instance in which I have tied an artery at a distance from the source of bleeding has hæmorrhage recurred, yet success must be regarded as *accidental*, because the vascular chain being broken, the effects of reaction and the moment of the establishment of the collateral circulation cannot be foretold with certainty. It may be questioned whether in the upper extremity, at any rate, ligature of the brachial would be a remedy for a small primary bleeding from the hand. Doubtless the more or less exhausted condition in which the patients are when this operation is resorted to, consequent on repeated loss of blood, tends to a successful issue from one point of view—the hæmorrhagic.

Whether to ligature one or both arteries in the forearm, holding the brachial in reserve, or to tie this latter in cases of uncontrollable bleeding from the hand, is a vexed question still. I prefer the latter—it is further from the lesion, and lying among comparatively sound structures, where the wound is less likely to be contaminated by unhealthy secretions, and more ready to take on reparative action.

The varying arterial distribution to the hand renders the result of deligation of the radial and ulnar vessels uncertain. Repeated hæmorrhages are both exhausting and alarming to a patient, while repeated operations are painful and harassing, and also discreditable to surgery in the estimation of the public.

Should hæmorrhage recur *after* the brachial has been ligatured, *compression* at the original wound would probably be effectual.

When securing the brachial, a possible high division must not be forgotten; if found, both arteries must be tied.

LIGATURE OF RADIAL ARTERY.

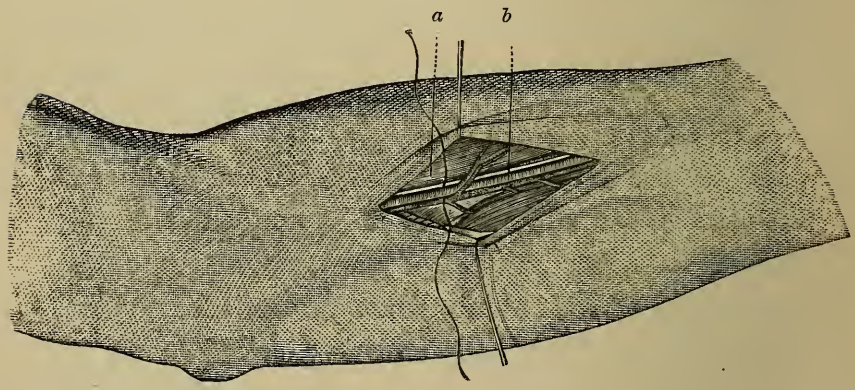
Anatomical Relations.—This vessel, the smaller of the two terminal branches of the brachial artery, extends from the middle of the bend of the elbow to the root of the thumb, when it turns backwards to the hand. It is comparatively superficial in its whole extent, especially in the lower half of the forearm. The artery is bounded on its outer side throughout by the belly and tendons of the supinator longus muscle; on the inner side it is bounded in its upper third by the pronator teres muscle; in its lower two-thirds by the flexor carpi radialis tendon. In a muscular subject the belly of the supinator longus muscle overlaps the upper portion of the radial artery.

OPERATION.

The radial artery may be ligatured at any point in the forearm, as, for example, in the upper and lower thirds.

Ligature in the Upper Third.—In this position, before commencing the operation, the situation of superficial veins should be noticed, and by manipulation a groove may be traced downwards by the finger, marking the spot at which the bellies of the

Fig. 13.

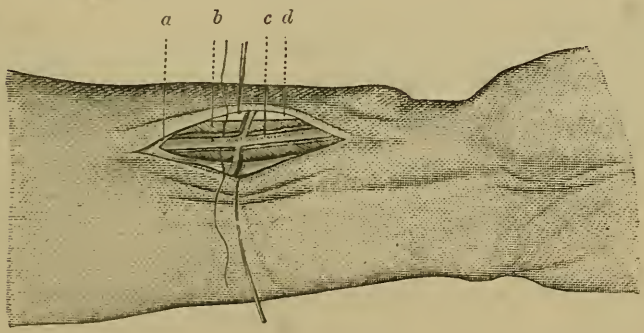


supinator longus and pronator radii teres muscles are in apposition. Along this groove, over and parallel to the course of the artery, an incision (Fig. 13) two inches in length should be made, dividing the skin and superficial fascia; the deep fascia should be slit up on a director, and after flexing the forearm slightly, so as to relax the neighbouring muscles, and drawing aside the supinator

muscle (*a*), the sheath containing the radial artery (*b*) and its venæ comites will be exposed, as also the radial nerve, to the outer side of the vessels. The ligature may be passed from without inwards.

Ligature at the Lower Third.—Here the vessel lies external to the tendon of the flexor carpi radialis muscle, which latter can be readily detected through the skin by manipulating the hand. An incision an inch and a-half in length (Fig. 14) should divide the integuments, just external to the

Fig. 14.



above tendon. Slit up the deep fascia (*a*) on a director, and having opened the sheath, pass the ligature around the artery (*c*), so as to avoid including either vein (*b*). The radial nerve does not accompany the artery in the lower third of its course. In a thin subject the vessel will be quickly reached.

LIGATURE OF ULNAR ARTERY.

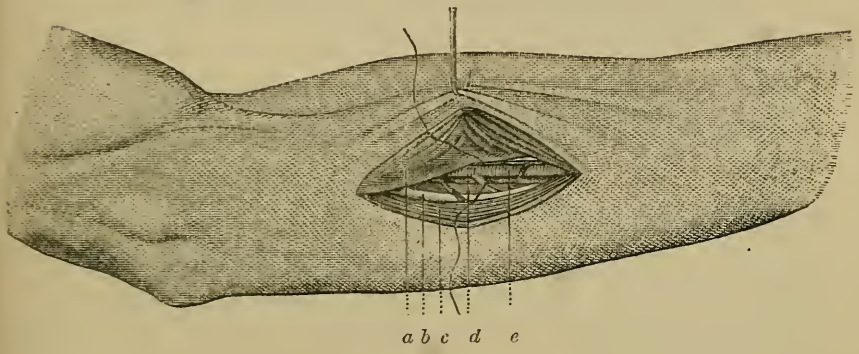
This vessel, the larger of the two terminal branches of the brachial artery, is covered in by the superficial layer of muscles arising from the inner condyle. It extends from the centre of the bend of the elbow in a curved direction, the convexity looking inwards, to the outer side of the pisiform bone. The artery is thus deeply placed, and can only be ligatured with comparative ease in its lower third, in which position even it is not so superficial as the radial artery. The vessel may also be exposed at the junction of the middle with the upper third of the forearm.

OPERATION.

Ligature in the Upper Third.—A line drawn from the apex of the internal condyle, downwards and forwards, to the outer side of the pisiform bone, will indicate the anterior and outer margin of the flexor carpi ulnaris muscle. The forearm being extended, an incision begun three fingers' breadth below the point of the inner condyle must be carried downwards in the direction indicated along the inner side of the forearm, dividing the integuments to the extent of three inches. Separate the edges of the wound and look for a white pearly line, also running towards the hand, and indicating the

septum between the flexor carpi ulnaris muscle on the inside and the flexor sublimis muscle on the outside; divide this aponeurotic line to the same extent as the integuments, taking especial care to get *between* the two muscles above indicated, and not into the substance of either. Flex now the hand and the forearm, and separate the superficial set of muscles behind which the artery lies, from the flexor profundus digitorum upon which the vessel lies, with the forefingers. The ulnar nerve

Fig. 15.

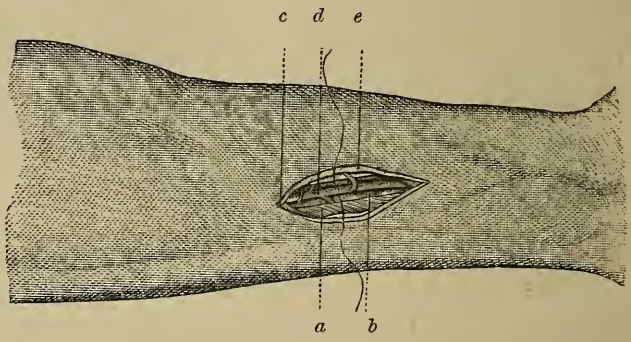


will be first seen, and soon, external to it but on the same plane with it, the ulnar artery with its venæ comites will be reached. Fig. 15 shows the operation above described and the parts interested: the flexor sublimis muscle (*a*) pulled aside, the ulnar nerve (*b*) resting on the flexor profundus muscle (*c*), the ulnar artery (*e*), with its venæ comites (*d*).

Ligature in the Lower Third.—Here the artery lies between the tendons of the flexor carpi ulnaris

muscle on the inside, and slightly overlapped by it, and the flexor sublimis on the outside. The hand being supine, make an incision (Fig. 16) two inches in length over the tendon of the flexor carpi ulnaris

Fig. 16.



muscle, dividing the integuments (*c*) and the deep fascia (*e*) on a director; flex the hand, and draw inwards the tendon of the flexor carpi ulnaris muscle (*a*) which overlaps the artery (*d*), and having opened the sheath pass the ligature from within outwards, so as to avoid both ulnar nerve and venæ comites (*b*).

CONCLUSIONS.

From the above cases of hæmorrhage we may conclude:—

I.—That no operation is to be performed when bleeding has ceased, unless a repetition of it would directly endanger life.

II.—That the bleeding vessel is to be sought at the seat of injury, and to be secured, if divided, at

both ends, either by a ligature or by torsion; if only wounded, by a ligature above and below the wound; or after section, by torsion.

III.—That the injured vessel is only to be tied on the cardiac side of, and at a distance from, a wound in it, when the attempt to secure it at the wound has either been made and failed, or when such an attempt would be either anatomically injurious or pathologically useless.

IV.—That it is desirable to ligature the brachial artery rather than both radial and ulnar, for secondary hæmorrhage from the hand.

V.—That ligature of the brachial, while it stopped bleeding, also arrested destructive inflammatory changes caused by useless local efforts to check hæmorrhage.

VI.—That blood, flowing from the distal side of a wound in an artery or ligature upon it, will in the lower extremity be often, in the upper extremity occasionally, *venous* in colour.

VII.—That in malignant disease, when the growth cannot be removed and it is impossible to check bleeding by milder measures, the feeding artery may be ligatured in its continuity.

VIII.—Where a part is more or less disorganized and hæmorrhage renders repair very doubtful, amputation should be performed both to arrest bleeding and to remove a hurtful member.

IX.—Indirect compression will occasionally arrest severe bleeding.

X.—That both the axillary and the femoral arteries may be wounded and a pulse be felt at the extremity of the limb.

XI.—That a wound in an artery may be recognized by the warm blood impinging on the inserted finger.

XII.—That direct compression upon the bleeding point will often succeed *after* the main artery has been tied, though it failed *before*; and this fact is a justification for tying a main vessel.

THE LIGATURE.

Of the various substances, whether animal, vegetable, or mineral, which have from time to time been employed for the ligature of arteries in their continuity, silk has been the most highly approved. But the fact that trials of other substances have been made is an indication that something is wanting even in silk.

To secure the obliteration of an artery, a sufficiently strong, fine, round, and firm thread is used and tied tight, with a view to cut through and maintain in apposition the two inner coats of the vessel, and to strangulate the outer. Thus, the ligature employed as a curative agent at once inflicts an injury which not unfrequently has a fatal result. To be successful, it must give rise both to a *reparative* process in the shape of *adhesion* of the cut surfaces of the divided coats, and to a *destructive*

process in the shape of *ulceration*, by which the ligature is to be cast loose, holding sometimes in its grasp a small slough of the constricted outer coat of the vessel. Should adhesion fail, or ulceration exceed certain limits, the operation may be destructive to the patient. Independently of the above processes, the formation of a coagulum in the vessel on both sides of the ligature is a safeguard against hæmorrhage, although not essential to prevent it when firm adhesion has occurred. It should, however, be encouraged, and with that object in view the surgeon elects, when he can do so, to place his ligature at a distance of not less than an inch and a-half from a known branch. He does this, because observation has shown that the proximity of a branch to the ligature through which former, blood is rapidly passing, is inconsistent with clotting, as is shown by this drawing from Lister,* and also by my case.

The brachial artery was tied (Case 17, p. 115) and the patient died of pyæmia on the eleventh day. Union of the divided coats had taken place, but there was clot on the distal side only. On the proximal side a vessel came off near to the seat of ligature.

Lister and Callender have suggested that one reason why coagulation takes place more readily on the cardiac than on the distal side of a ligature, is because of the turmoil into which the blood is thrown when impelled with force against an obstacle. At the same time, a certain length of vessel between the

* *Lancet*, April 3rd, 1869.

next branch and the ligature in which the blood may be whipped up and yet be uninfluenced by the current, is requisite. The above case illustrates these points, because, although a small clot had formed on the distal side of the ligature and the blood might be expected to be in a state of comparative repose there, yet, knowing how free is the anastomosis in the upper extremity, it probably was, on the contrary, much agitated. And this free anastomosis, by promoting the deposit of a tolerably firm clot on the distal side of the ligature in the upper extremity, is one reason why secondary hæmorrhage is comparatively rare in this region of the body. This churning process leads to the deposit of fibrine more or less pure in proportion to the disturbance, and thus a firm obstacle to secondary hæmorrhage is presented above the ligature. On the other hand, we cannot ignore the apparent fact that the formation of *blood-clot*, in contradistinction to pure fibrine, is favoured by slowness of movement of the fluid holding it in suspension. Consequently where the anastomosis is not very free, as in the lower extremity, the deposit of soft blood-clot, rather than of fibrine, may be expected on the distal side of the ligature. Supposing then, from any cause, a small aperture to exist in the vessel on the distal side, and before this soft clot shall have become consolidated, the force of the blood propelled against it may be sufficient to wash it away, and so secondary hæmorrhage occurs. The instability of soft clot is recognized in some cases of aneurism

cured by both the rapid method of compression and by ligature, in which the circulation is re-established after apparent cure, as in Mr. Spence's case, where flexion afterwards succeeded.

The operation performed by a ligature upon an artery corresponds as nearly as possible, so far as the vessel itself is concerned, to a *subcutaneous* operation, the two inner coats being severed under cover of the outer; and possibly this fact it is which often favours adhesion, even though the injury inflicted be a *contused* wound. But, added to this concealed injury, we have strangulation of the external coat and its attendant consequence — ulceration.

Herein lies the weak point of the ligature!

Now and then an artery is cut down upon, and a ligature of silk, or of gut, or of wire, or of catgut having been applied and cut short, the wound closes by primary union over the foreign body, but this result of the operation cannot be relied upon.

With the hope of obviating the casting off by ulceration of the ligature, Dr. Jones,* about seventy years ago, made experiments on horses and dogs, and showed that after tying two or three ligatures tight upon an artery and immediately withdrawing them, obliteration of the vessel at the seat of injury occurred without destruction of the outer coat, and consequently without loss of continuity.

Mr. Lister's experiment on a calf is also in-

* Dr. J. F. D. Jones, "On Hæmorrhage," 1805.

structive.* He tied the carotid artery of a calf *antiseptically* with an animal ligature, and at a post-mortem examination, made thirty days after, found it embracing the artery, and organized.

The information thus derived by these two experimenters would be of the utmost value were we called upon to treat the lower animals; but, until we know by actual practice on man what the result of operations performed in a similar manner is, no useful conclusions can be reached. Webber's forceps, intended to sever the inner coats and then to be withdrawn and the wound closed, though meant to act on the same principle as, what I may term, Jones's *momentary* ligature, has the disadvantage of dividing the inner coats at two points and including and compressing between these about one-sixth of an inch of the calibre of the vessel.

Theoretically, the chief risk which the use of either Jones's momentary ligature or Webber's forceps would entail, would be secondary hæmorrhage, supposing the bruised external coat to slough before the channel of the artery had become obstructed by adhesion. But if, in man, *adhesion* and obliteration while blood is traversing the injured part of the vessel are not a necessary consequence and *sloughing* is a necessary result of the method employed, the effect will be disastrous.† A temporary ligature, applied for a few hours only and

* *Lancet*, April 3rd, 1869.

† L. Holden, "Barth. Hosp. Reps.," vol. viii. p. 187.

then removed, was tried by Sir Astley Cooper and others, and yielded the most unsatisfactory results.

Our great aim should be, out of a variety of means, to select that which commends itself at first theoretically and then stands the test of experience.

I shall now consider the last novelty—

THE ANTISEPTIC METHOD.

It is not necessary to inquire here how this antiseptic method operates. All will accept that it is desirable to prevent putrefaction and to promote rapid closure of wounds. To this end carbolic acid is used, and catgut, *properly prepared*, is advocated by Mr. Lister to replace the time-honoured silk thread.*

Since the introduction of the antiseptic ligature I have resorted to it on eight occasions (*nine* arteries tied), using various materials, sometimes *cut short*, at others left *projecting at the wound.*

No. 1.—In case 12,† that of a child whose femoral artery I ligatured to arrest traumatic inflammation associated with an opened knee-joint, I employed fishing-gut, protecting the wound with dressings of carbolic oil and lint. The ligature was cut short, and for several days there was no secretion from the wound beyond serous oozing; and

* *Lancet*, April 3rd, 1869. † Page 148.

TABLE OF MR MAUNDER'S EIGHT CASES OF LIGATURE OF ARTERIES IN THEIR CONTINUITY ON THE ANTISEPTIC CARBOLIC METHOD.

Case.	Sex	Age	Nature of Disease or Injury.	Operation.	Result.	Remarks.
1* 2	M	37	Aortic aneurism (supposed innominate)	Ligature of common carotid and of third part of subclavian simultaneously, Sept. 18th, 1867	Died on the sixth day	Antiseptic *silk* ligature, *long*, was used; no suppuration.
3	M.	46	Axillary aneurism.....	Ligature of subclavian, third part, March 18th, 1871	Died on the ninth day	Antiseptic *catgut* ligature, *cut short*, was used, and is still on the artery; decomposition occurred in the wound; diffuse cellulitis; pericarditis.
5	M.	26	Carotid aneurism at bifurcation, left side	Ligature of common carotid, Sept. 22nd, 1868	Recovered	Antiseptic *silk* ligature, *cut short;* healed in a few days without suppuration. Ligature still on artery (January, 1875).
6	M.	32	Femoro-popliteal aneurism	Ligature of superficial femoral, May 17th, 1872	Recovered	Wound healed by primary union over antiseptic *catgut*, *cut short.*
7	M.	42	Popliteal aneurism	Ligature of superficial femoral, June 16th, 1872	Recovered	Antiseptic *catgut* ligature, *cut short;* wound quickly suppurated.
12	F.	3½	Open knee-joint.....	Ligature of superficial femoral, April 29th, 1869	Recovered	*Fishing-gut* antiseptic ligature, *cut short;* no suppuration for several days.
14	M.	31	Wound of wrist; secondary hæmorrhage	Ligature of brachial artery, Nov. 16th, 1871	Recovered	Antiseptic *catgut*, *cut short.*
17	M.	28	Suppuration of hand and secondary hæmorrhage	Ligature of brachial artery, March 11th, 1873	Recovered	Antiseptic *catgut*, *cut short.* Died of pyæmia on the 11th day. No ligature to be found. Inner coats of artery divided and united by adhesion.

* Two arteries tied.

The numbers correspond with Mr. Maunder's Table of Arteries attached to Lecture I., pp. 2, 3.

probably its deeper parts healed quickly, although the surface after a time secreted pus.

No. 2.—In case 5, that of a gentleman whose left common carotid artery I ligatured, dentist's silk, soaked previously for some hours in a very strong solution of carbolic acid, was used and cut short. The wound from time to time during the operation was flooded with a solution of carbolic acid, and after the sutures had been introduced it was covered up with carbolic putty. A little serous oozing alone occurred, and within a fortnight the wound was soundly healed, and remains so to this day.

No. 3.—Case 1. That of a man whose carotid and subclavian (third part) were tied simultaneously with carbolized silk left projecting at the wounds. The patient died on the sixth day.* No suppuration had occurred.

No. 4.—Case 3. A male, whose subclavian I tied antiseptically with catgut, cut short. Decomposition occurred in the wound. The patient died of diffuse cellulitis and of pericarditis. In the preparation the ligature still embraces the artery.†

No. 5.—In case 14 the brachial artery was ligatured for secondary hæmorrhage from the wrist, with catgut, cut short. The wound remained open superficially an unusually long time. The man was very feeble from loss of blood.

No. 6.—In case 17 the brachial artery was ligatured with catgut, cut short, for hæmorrhage

* Page 26. † Lond. Hosp. Mus.

from the hand associated with suppuration and sloughing. The patient died of pyæmia, on the tenth day. At a post-mortem examination no ligature could be found, but the coats of the artery were adherent at the point of compression by it. It will be observed that the catgut ligature, though applied only ten days previously, had disappeared; a fact which, in the estimation of many, will weigh against its use.

No. 7.—Case 6. Catgut ligature of the superficial femoral artery for popliteal aneurism, cut short. The wound was soundly healed in a week.

No. 8.—Case 7. A catgut ligature, cut short, to the superficial femoral, under precisely similar circumstances to the former. This wound quickly suppurated and remained open many weeks.

I have also witnessed two other instances in which catgut was employed antiseptically. One, that of my colleague, Mr. Couper.

The patient was the subject of carotid aneurism, which extended low down into the neck. The operation was necessarily a difficult one, and a great deal of time, trouble, and manipulation were expended before the artery could be reached, and this close to the sac, which was both seen and touched. I thought at the time that diffuse cellulitis would certainly follow; but, on the contrary, I was agreeably surprised to find that, with the exception of a very little serous oozing, the wound was healed in about a week. It certainly

was a striking instance of rapid healing under apparently very adverse circumstances.

The other case, that of Mr. McCarthy, mentioned in my former lecture, was one of simultaneous ligature of the subclavian and common carotid. Catgut, cut short, was used antiseptically. Decomposition occurred in the subclavian wound. The patient died of hæmorrhage from the cardiac side of the subclavian ligature on the fifteenth day. At the post-mortem examination the ligature was found upon the subclavian artery, the latter having a small hole in it corresponding in position to the knot. It had not divided the inner coats. The carotid wound had nearly healed. No ligature could be found here, but a considerable quantity of thickened connective tissue had been developed at the seat of ligature. The coats of the artery were not divided, and there was a little clot at both the proximal and distal sides of the ligature. The aneurism was aortic.

Of these ten patients two died (Case 3 of mine, and McCarthy's) of causes occasionally associated with the application of a ligature to the third part of the subclavian artery—hæmorrhage and diffuse cellulitis, the latter giving rise to pericarditis and pleuritis. These two are the only cases in which death may be fairly ascribed directly to the ligature.

Case 17 of mine also died, but of pyæmia; and, although no ligature was found upon the artery,

repair was taking place in it, notwithstanding the unfavourable general condition of the patient.

Case 1, 2 of mine also died, not from the direct application of the ligatures to the carotid and subclavian. The wounds remained perfectly antiseptic, and had the patient survived, it may be fairly assumed from that fact, and also from the post-mortem appearances, that the threads would have come away favourably.

Cases 15 and 16 were a long time in hospital before the operation wounds healed; and it may be fairly suggested that a more favourable set of symptoms would not have followed the application of the silk ligature in the usual way, by reason of previous loss of blood.

Cases 6 and 5 are examples of rapid healing, while the ligature, in the one case silk, in the other catgut, remained permanently on the artery. No more satisfactory result could be desired.

In contemplating this list of cases with a view to determine the value of the antiseptic methods of ligature, the question to be asked is: Could an equally or more favourable result have been anticipated had the usual operation with the silk ligature been performed? My reply will be in the negative.

I will now add to the above a little more of the experience of others.

Mr. Lister informs me (January 2nd, 1875) that he has tied six arteries antiseptically, one with silk

and five with catgut, cut short (one external iliac, one common carotid, four femoral). He says:—"One of these latter is remarkable, from the fact that the aneurism reached to the upper part of the thigh, so that I was induced to apply the ligature at a situation which I should not have thought expedient without antiseptic means; namely, about the most frequent place of origin of the profunda." In each instance he had every reason to believe that the ligature remained upon the artery, and consequently its continuity was not destroyed; and this is the grand desideratum and that which Mr. Lister claims for his catgut. In contrast to the above it is only right to record instances in which the catgut ligature has been attended by peculiar and unsatisfactory results.

A male, thirty-eight years of age, came under the care of Mr. E. Watson,* with popliteal aneurism, on Sept. 7th, 1869. Three years previously he had been cured of an aneurism in the same locality by ligature of the femoral in the usual place.

September 10*th*.—An antiseptic catgut ligature was applied to-day in Hunter's canal, but without arresting pulsation beyond a few seconds.

15*th*.—A similar operation is performed upon the external iliac artery. A discharge takes place at the wounds, but the ligatures did not come away. Death, after amputation, on October 15th.

Post-mortem.—Operation wounds are granulating

* *Glasgow Med. Journ.*, May, 1870, p. 340.

superficially. The external iliac artery, when "slit up, had its lining smooth and unbroken, and there was no evidence left of diminution of the calibre of the vessel. Neither was there any trace of the catgut, and the impression on my mind is that the ligature did not confine the vessel for more than a few hours —a sufficient length of time, however, to produce partial coagulation of the blood in the aneurismal sac: for the pulsation never returned. Another curious circumstance is, that the vessel at this place was quite empty—there was no clot or even a shred of lymph adherent to this part of the vessel. . . . . Tracing the artery further down, its calibre was found much diminished at the position of the first ligature, which was a silk one, and its coats, as well as the tissues in the neighbourhood, were considerably thickened. At the site of the ligature which was placed on the artery in Hunter's canal, it should be mentioned that the coats of the vessel were very deeply reddened, and it was filled with an adherent clot; but, nevertheless, its calibre was not diminished. There was no trace of this ligature—a catgut one—to be discovered."

Dr. E. Watson replies to me, January 16th, 1875, concerning the above: "The ligatures were faultless and their application was most careful. I think Mr. Lister assisted me in one of the operations, as he was my colleague here at the time. I confess it is curious, but true, that though this failed as a ligature when applied in continuity, I am constantly in

the habit of tying vessels in stumps with catgut, and I never have secondary hæmorrhage. I have had easy success with silk ligatures on the femoral, and I do count them more secure than catgut ones for tying the artery in continuity, because they cut and come away. The others do not cut, and only hold the artery for a few hours. This does not seem enough in the case of large arteries, unless they are cut as in amputation, when they retract and so stop up the orifice. I know that others have succeeded with catgut ligatures applied for aneurism. But the artery may not have been obliterated, though coagulation took place in the sac."

Second instance. Mr. Spence writes :*—"On Wednesday, May 12th, having occasion to tie the right common carotid artery, I determined to use the catgut ligature. I exposed the artery very carefully, and passed the ligature with the least possible disturbance of its connections. The patient was very comfortable during the afternoon, with the exception of sickness from the chloroform when he took liquids. On Thursday morning, at half-past ten, I received a message to say that he had suddenly become comatose and paralyzed on the left side. . . . The patient died on the morning of the 15th. On examining the carotid artery I was not a little surprised to find that it did not seem in the slightest degree constricted at the point of delegation; in fact, at first I saw nothing that I could recognize as the ligature. On

* *Lancet*, June 5th, 1869.

careful examination, however, I found that what at first seemed some lymph or tissue was the catgut softened. . . . On looking at the ligature with a pocket lens the texture of the catgut was distinctly seen, but it was so gelatinous and pulpy that it seemed as if it were cast in gelatine; and a portion removed for microscopic examination, when placed between two slips of glass, spread out like a fluid. . . . An embolic clot was found plugging the middle cerebral artery."

In a private letter just received from Mr. Spence (Jan. 8th, 1875), he says to this effect: "I obtained the ligature from Mr. Syme's department, where it was in use. I tied it very tightly and had the first turn of the knot fixed by the handle of an instrument while I formed the second, completing the reef knot, and as I was to cut the ends short, I tied a *third* knot. The ligature had softened (not slipped) and lost its constricting power. The internal coats of the artery are cut through, as with the silk ligature, but when the catgut softened the force of the circulation, I presume, distended the vessel and forced the fragments of the recent clot into the circulation. I use carbolized catgut to tie arteries in amputations, removal of tumours, etc., but I certainly would *not* use it to tie a large continuous trunk for aneurism again. Its very advantages for ordinary use arise from its softening and dissolving, and so disappearing insensibly without ulcerating through the cellular fibrous coat of the vessel. I have known hæmorrhage occur

after amputation from the ligature softening and losing its constrictive power. When I use it in large arteries—as in thigh amputations—I apply two ligatures, one close to the soft parts, another near the open mouth of the vessel. I now for large arteries in amputation use catgut for the upper ligature, but dentist's silk for the lower, so that if the catgut should soften before the hæmostatic changes are complete, the good old silk holds. But as the catgut does not ulcerate through the external coat of the vessel, I think it a security, and it does not seem to produce irritation."

Again: On May 25th, 1871, Mr. Holden ligatured the femoral artery in Scarpa's triangle antiseptically with catgut.* Venous bleeding occurred at the time, and pulsation in the aneurism ceased.

26*th*.—Slight pulsation in aneurism.

27*th*.—Considerable pulsation.

29*th*.—Still marked pulsation.

30*th*.—Pulsation somewhat diminished in force.

31*st*.—Pulsation is more diffused than before. Discharge of *fœtid* green pus from the wound.

June 2nd, 2.30 a.m.—The patient is lying in a pool of blood, and died to-day.

Post-mortem.—"At the point where the vessel was tied there was a jagged perforation of the arterial coats through which the hæmorrhage had taken place. Not a trace of the ligature could be found after most careful search. On slitting up the canal

* "Barth. Hosp. Reps.," vol. viii. p. 187.

of the artery the inner and middle coats were seen to be fairly divided. There was no trace of any clot, the vessel being pervious throughout."

An interesting experiment concerning the tenacity of catgut under two conditions has been instituted by Mr. Callender, and the results, in the shape of these preparations, I am enabled, by that gentleman's permission, to show you.*

Now these instances of failure naturally tend to encourage distrust of the catgut, and more especially when the accidents are peculiar and such as are not met with in the use of silk. Possibly these accidents might be explained to the satisfaction of the majority of operators, but any one of these mishaps occurring to an individual would make him at least disinclined to a repetition of the catgut, and such, in fact, was the effect produced on the minds of Mr. Ebenezer Watson and Mr. Spence who, in consequence of their experience above quoted, have reverted to the silk ligature. These recorded accidents teach us one very important fact: that however possible it may be to obliterate an artery in the lower animals, as was done by Jones, and which was suggested by him as possibly applicable to the human subject by the momentary ligature, disastrous failure must be expected, and this method must not be repeated. One cannot therefore agree with Mr. Lister, with our present experience of the catgut ligature, that it is probably a "matter of

* "Path. Soc. Trans.," vol. xxv. p. 103.

indifference" whether or not the wall of the vessel be left intact in tying it. So long as the ligature of an artery cannot be guaranteed against the minimum degree of suppuration, ulceration, and sloughing, and while the catgut may melt away before repair has taken place, so long will its employment be attended by anxiety. For the surgeon distrustful of catgut, there is yet one resource well worthy of further trial.

I allude to the antiseptic silk ligature, cut short.

Mr. Lister's first application of the antiseptic ligature was that of silk, cut short, to the external iliac artery of a female, fifty-one years of age. This patient died between ten and eleven months subsequently, and he had an opportunity of examining the parts concerned in his operation. He found a remnant of the ligature only, and something very like pus near it. This condition of the ligature, after a lapse of ten months, induced Mr. Lister to resort to catgut, as probably being less irritating than silk.*

My own case (5) was operated upon in a similar manner, in consequence of the publication of the history of the above. My patient is still alive, six years having elapsed, and indeed he is here present to-night. We can speculate to no profit as to the fate of his ligature. Referring to my cases of antiseptic ligature, only one—Case 6

* *Lancet*, April 3rd, 1869.

—in which the wound closed by primary union over the catgut, can be fairly contrasted with this. All the others differed in some particular, and disadvantageously.

Both gut and silk, cut short, were used by Cooper, Guthrie, Lawrence, and others, but the result was so unsatisfactory that they were discarded for the usual method. But it is quite possible that the silk ligature, cut short, and used antiseptically, may, in the majority of instances, remain quiescent; and by maintaining its hold upon the artery for a sufficient length of time to admit of repair, as we know it will do, will supersede even catgut.

For my own part, I am disposed to repeat the use of antiseptic catgut until further experience declare against it, using a large size for an artery in continuity.

In a private letter to me on this subject, Mr. Lister now advises the use of a drainage tube for the first few days after an operation, to prevent the accumulation of serous oozing, withdrawing the tube by degrees.

Again, it will be observed that in one case, No. 1, 2, in which I tied the subclavian and common carotid simultaneously, I used a silk ligature in the usual way, but antiseptically. This plan may commend itself to some, and more especially as the ligature, projecting at the wound, will serve the purpose of a drainage tube; and there is probably

no reason why antiseptic catgut should not be used in a similar manner.

In proposing to resort to the antiseptic method, it is only fair to the originator of it, and to avoid bringing it undeservedly into discredit, and for the welfare of the patient, to carry it out in all its details; a somewhat troublesome undertaking, but which will probably repay the operator by its results. This close attention to details is the more necessary, because, as I have said, Astley Cooper, Porta, and others, tried catgut (not antiseptically), but reverted to silk.

I wish it to be particularly observed that my remarks and cases had especial reference to the use of this ligature in the *continuity* of arteries. It has been very freely used at the extremity of a divided artery, and as is firmly believed, with advantage over silk; but it must not be inferred from this fact that the conditions of the ligature correspond. In a stump the artery, retracting and contracting, is soon put into a state of rest, and blood only in proportion to the wants of the now diminished limb passed into it; and thus an opportunity for resisting hæmorrhage and repairing injury is quickly afforded. On the other hand, the vessel ligatured in continuity remains in a state of tension for a longer or shorter period, and the above-mentioned conditions are consequently postponed. I would suggest that the catgut be employed double, and

the artery being at once severed between the two ligatures will be placed in repose immediately.

After mature consideration I arrive at the following conclusion, that the fate or behaviour of a given antiseptic catgut ligature, applied to the continuity of an artery, cannot be foretold.

LECTURE III.

ON LIGATURE OF A MAIN ARTERY TO ARREST ACUTE TRAUMATIC INFLAMMATION.

The special subject of my discourse this evening—ligature of the main artery to arrest acute traumatic inflammation*—was, when suggested to the profession by me, a novelty in Europe; but, inasmuch as I afterwards learned to my chagrin, that it was not so in America, I must, for both reasons, be allowed to give you a brief history of the matter, and to relate the illustrative cases somewhat in detail. A little time previous to this operation I had heard of *compression* of arteries being employed as a means to arrest inflammatory action. This information led up to the idea that *ligature* of the main artery would be a more effectual method.

It will doubtless be accepted that cases of acute inflammation (of joints for example) require speedy and active interference in order to bring about resolution—an admission in favour of the ligature. On the other hand, supposing *compression* to be resorted to,

* "Lond. Hosp. Reports," 1867.

and for some reason or other to be relinquished too soon, blood would then not only pass to the inflamed spot through the enlarged smaller vessels, but also through the main channel, and thus an additional and injurious supply would result.

On *May* 13*th*, 1867, I recommended the ligature of the femoral artery in a case of wound of the knee-joint, followed by traumatic fever and acute inflammation below, about, within, and above the knee. The man who had sustained the accident was under the care of my then and much-esteemed colleague, Mr. L. S. Little, and that gentleman tied the superficial femoral artery with immediate and striking relief to symptoms. The patient, who was in imminent danger of losing, possibly, both limb and life, was from that moment in comparative safety, and made a good recovery.

Lacerated Wound of the Knee-joint; Acute Inflammation; Ligature of Superficial Femoral Artery; immediate Relief; Recovery.—Joseph C—— was admitted into the London Hospital, under the care of Mr. L. S. Little, on May 3rd, 1867, having sustained a lacerated wound opening the knee-joint. When seen by Mr. Disney Thorpe, the house-surgeon, an hour after the accident, synovia was escaping. The wound was closed with three silver sutures; a back splint was applied, and the joint surrounded with bags of ice. He passed a good night without pain. The next day there was some effusion into the joint, but there was no heat nor constitutional disturbance.

May 5th.—Effusion less. Patient very well. Ice to be continued, as he complains of pain if fresh ice is not frequently applied.

May 6th.—So well that he was placed upon full diet.

May 11th.—There is some redness along the inner side of the knee, and some pain.

May 12th.—Knee-joint much increased in size; red, and tense with fluid. Great and incessant pain, which is much aggravated if the joint be touched.

May 13th.—Joint still more swollen. It feels hot, notwithstanding the continued application of three large bags of ice. The redness has extended some distance up the thigh, particularly on the inner side where the tissues are brawny; also down the leg. Patient is suffering much from pain and sleeplessness, with a pulse of 120, anxious countenance and general constitutional disturbance. At 10 a.m. he had a rigor.

I now saw the patient in consultation with Mr. Little, and proposed the ligature of the superficial femoral artery as a means of arresting the inflammation. Mr. Little, courteously acting on my suggestion, boldly and dexterously tied the artery at once (4 p.m.) at the apex of Scarpa's triangle, the patient being under the influence of chloroform. The redness paled somewhat at once, and the patient, on recovering from chloroform, remarked with surprise and delight, "My pain is gone!" Half-an-hour after the operation the pulse was 100, having pre-

viously been 120. 10 p.m.—No pain since operation; thinks he'll sleep. Pulse 96. Less redness. Toes cold, but sensible to touch.

14*th*.—4 p.m. Toes warm; knee cooler and less red, but with a sense of numbness about it; pulse 90, feeble. Ordered, wine ʒvi.

15*th*.—3.30 p.m. Says he is "first rate;" better appetite; heat about the heel prevented sleep (pressure from splint), knee and thigh smaller and paler; the ends of the accident wound began to discharge very thick pus about two hours ago. Pulse 100, firmer; tongue cleaner.

16*th*.—4.30 p.m. The patient had some starting pains during the night, so that he slept badly. As the discharge from the knee was now considerable, the quantity of wine was increased to ten ounces. Pulse 98.

17*th*.—During the night he had a profuse sudden bleeding from the nose.

June 1*st*.—Ligature removed to-day. Has gone on uninterruptedly well, with the exception that the wounds have been very slow in healing and showed little power, particularly that on the thigh, which discharged very freely.

June 26*th*.—Sat up to-day.

P.S.—The patient gradually regained the use of his limbs, and acquired free motion to the extent of 20°.

Three months later the man was quite well, but the range of motion appeared to be limited by

thickening outside the joint. He refused further interference, as he could do his work satisfactorily. He is here to-night.

I need scarcely say that when this idea of mine had been put in practice (1867) with pre-eminent success, it created considerable discussion in the profession, and many surgeons came to see the case. Since that time certain articles on "inflammation," published in this country, have advocated this as one of the methods of treatment. Mr. Bryant says:* "To arrest acute inflammation in a limb, the delegation of the main artery of the limb, or the arrest of the circulation through it by pressure upon the artery has been adopted. Dr. Campbell, of New Orleans, speaks highly of the practice, and even affirms that no portion of an extremity should be amputated for destructive inflammation without the surgeon attempting the practice. Upon the suggestion of Mr. Maunder, of the London Hospital, in 1867, Mr. Little applied a ligature to the femoral artery for acute suppuration of the knee, with a success sufficient to prove its value; and the late Mr. Moore, of the Middlesex Hospital, acupressed the brachial artery with a good result."

Dr. Robert Druitt, in his article "Inflammation,"† naturally jealous for originality emanating from his own countrymen, says: "Mr. Maunder, of the London Hospital, has tied the femoral artery in several

* "Practice of Surgery," 1872, p. 454.

† Cooper's "Surgical Dictionary," 1872, vol. ii., p. 65.

instances of severe inflammation of the lower limb, and has spoken favourably of the results. Mr. Maunder's first case was so treated by him without any knowledge of the American experiences we have referred to, and his results were as satisfactory as those of Dr. Campbell. The late Mr. C. H. Moore also compressed the brachial artery for severe traumatic inflammation of the hand, acting on Mr. Maunder's suggestions; and in that case also the remedy had a very striking effect."

The advantages I claim for the ligature are best shown by a review of the above case.

Immediately on the application of the ligature, pain, previously severe, ceased; and with this cessation sleep and appetite returned. On the following day the countenance was changed from one expressive of physical suffering to that of repose, and in forty-eight hours the man pronounced himself to be "first rate." Symptoms of inflammatory action, both general and local, quickly subsided: redness paled, swelling disappeared, and the integuments previously rendered red, œdematous, and inelastic above, about, and below the knee, soon assumed their normal character. On the day of operation, Mr. Little and I were not sure whether or not pus was already formed (the man had experienced a slight rigor in the morning), but inclined to the opinion that a small quantity did exist immediately under the skin and middle of the line of the wound which was healed. We also thought it quite probable that the

synovial membrane of the joint had already begun to secrete pus. About forty-eight hours subsequent to operation, both ends of the original wound opened spontaneously and discharged pus, the matter flowing in small quantity, and as though it welled up from the interior of the joint. During this suppurative stage, the patient experienced no discomfort, with the exception of slight starting pains for one or two nights; and after the lapse of a few days, the discharge of pus, except from the surface of the accident wound, ceased.

Another and all-important advantage is that no blood is taken from the patient; and the subject of these remarks was in no condition to lose an ounce of the vital fluid.

Since then I have tied a main artery twice, with a view to arrest inflammation in a limb, and my colleague, Mr. Reeves, has ligatured the superficial femoral with a similar object. Also, in several instances in which the ligature has been used to stop bleeding, existing inflammation has ceased, and repair commenced.

The first of the former was that of a child whose knee-joint had been opened by a burn.

Open Knee-joint; Suppuration within and without; Ligature of the Femoral Artery; Recovery.—A. P——, aged three and a half years (case 12 in table of arteries),* was admitted into the London Hospital under care of Mr. John Adams, February 5th, 1869. She

* See next page.

TABLE OF MR. MAUNDER'S SIX CASES OF LIGATURE OF ARTERIES, WITH THE RESULT RESPECTING TRAUMATIC INFLAMMATION.

Case.	Sex.	Age.	Nature of disease or injury.	Operation.	Result.	Remarks.
12	F.	$3\frac{1}{2}$	Open knee-joint	Ligature of superficial femoral, April 29th, 1869	Recovered	Profuse suppuration; quickly arrested.
15	M.	38	Wound of hand; secondary hæmorrhage	Ligature of brachial artery, March 17th, 1865	Recovered	Acute suppuration and sloughing of hand, and great œdema of the extremity; quickly arrested.
17	M.	28	Suppuration of hand and secondary hæmorrhage	Ligature of brachial artery, March 11th, 1873	Recovered	Profuse suppuration; sloughing and swelling immediately arrested. Death from pyæmia.
18	F.	47	Inflamed hand	Ligature of brachial artery, July 22nd, 1870	Recovered	Very transient amelioration of symptoms. Death from pyæmia about two months later.
20* 21	F.	49	Suppuration and hæmorrhage from foot ..	Ligature of ant. and post. tibials, Nov. 16th, 1868	Died.	Hæmorrhage and suppuration ceased; gangrene; exhaustion.

* Two arteries tied.

The numbers correspond with Mr. Maunder's Table of Arteries, attached to Lecture I.

had sustained a severe scald by boiling water over the lower part of the abdomen and thighs, and especially of the right knee. She progressed favourably for several weeks when, on April 8th, the house-surgeon, Mr. Vialls, observed an abscess on the outside of the knee, which broke the following day.

April 10th.—The patient had recently come under my care (by reason of Mr. Adams's retirement from the office of surgeon), and at the site of the abscess a depression in the granulations admitted the little finger into the joint. The cavity contained pus, and an incision made on the inside favoured its flow.

April 19th.—Suppuration has spread round about the joint and up and down the limb, and incisions have been made here and there. A drainage tube was introduced to-day through the joint.

April 28th.—Limb is more swollen, and two more incisions are made. The discharge is very profuse, and the limb is dressed twice daily in consequence. Drainage tube removed. Eats and sleeps pretty well.

April 29th.—The whole limb is now œdematous from groin to toes, and pus can be squeezed out in large quantity at the various openings made from time to time. The child is very exsanguine and emaciated, but takes its food fairly, sleeps pretty well, and has a clean tongue.

3 p.m.—I placed a fishing gut ligature on the superficial femoral artery at the apex of Scarpa's triangle, on the antiseptic plan, everything coming

in contact with the wound having been treated with a solution of carbolic acid. The ligature was cut short, and the wound closed by three metallic sutures, and then covered in with layers of lint soaked in carbolic glycerine. The whole limb was carefully wrapped in cotton wool, and a flannel bandage and splint applied to secure immobility at the knee. A large piece of lint, saturated with carbolic glycerine, was laid upon the thigh.

There is nothing special to record concerning the operation; the vessel was deep by reason of the swollen state of the integuments, and a nerve larger than usual crossed the sheath towards its inner side; the femoral vein was not seen, and not a teaspoonful of blood was lost. The toes looked white and tallowy after the ligature of the vessel.

9 p.m.—Child is asleep; cries when the toes are touched, but moves them freely, they having very much the same appearance as the toes of the opposite member, and are equally warm to the hand.

30*th*.—3 p.m. Sitting up; clean tongue; no appetite; strong odour of carbolic acid; much less discharge; toes colder than those of opposite foot. To have six instead of three ounces of wine. To use as little carbolic acid as possible, lest it affect the child's general health injuriously, which it already probably has done.

May 1*st*.—Clean tongue; has eaten a little meat to-day. Removed the flannel bandage and cotton wool, and pressed the matter which had accumulated

since the operation. Incised a fluctuating swelling, giving exit to pus, which existed, at the time of operation, on the inside of the knee. The whole limb, excepting the operation wound, dressed from the foot upwards with strips of lint. Wool and bandage re-applied, and a back splint adapted.

May 2nd.—(Only seventy-two hours after operation). Nurse says the discharge is only a quarter as much as it was formerly. All swelling has subsided. Relishes food.

May 3rd.—Feels pretty well. There is a vesication on the heel (from pressure). The little pus discharged from the various wounds is very *thick* in character.

May 7th.—On exposing the operation wound today, it was found gaping and granulating, the sutures being detached by ulceration, but there was no discharge. The child takes milk, wine, eggs, and bread and butter freely, but very little meat. There is *not a tablespoonful* of discharge from the whole limb, now only the ninth day subsequent to operation.

It will thus be seen that the operation was markedly successful, the quantity of discharge being quickly reduced to one-fourth. Subsequent to the ligature, a small slough from continuous pressure formed on the heel, and I was very anxious about it. To my surprise the slough separated, and the wound healed as readily as though the normal circulation of the limb had not been interfered with. The child made a good recovery, although naturally weakly

and the subject of ophthalmia, for which it was treated by my colleague, Mr. James Adams.

Question of Operative Interference.—With reference to the history of the case up to the time of operation, it is evident that the progress of the condition of the limb was from bad to worse. In the first instance, when the joint was found to have been opened, swelling and suppuration seemed to be restricted to its interior, but soon these limits were overstepped, and pus was found round about the joint on all sides. To give free exit to this, incisions were made, and a drainage tube was passed through laterally, one end of the tube appearing on the inside of the articulation and the other in the popliteal space, to give exit to matter existing in that locality and to favour gravitation. The original wound on the outside of the joint allowed the matter to escape in that region. In the course of a few days, further incisions were necessary above the knee, and on the day before operation, matter had burrowed half-way up the thigh and half-way down the leg, and an incision in both situations gave exit to a large quantity of offensive discharge. On the day of operation, the whole limb was œdematous, probably as a prelude to or co-existent with further diffuse suppuration. Now, although the child's general health was fair, still the local symptoms threatened to become worse rather than to improve; and if the former state resulted, not many days would elapse before either hectic or typhoid

symptoms would arise, when in the former case proximate safety would lie in amputation; but in the latter there would be no hope of recovery. By ligature of the femoral artery, I hoped to save both life and limb.

By resorting to the ligature, I of course believed that suppuration would in great measure be arrested, and that amputation or death, necessitated by exhaustion, would be prevented. Also, I am of opinion, of two evils—profuse suppuration or ligature—I had selected the lesser, because I have not that dread of the consequences of ligature of the superficial femoral artery, under certain conditions, which some surgeons profess.

I was greatly induced to operate in this case, in consequence of an observation made in Mr. Little's case just related. A few hours before Mr. Little operated, his patient had had a rigor, and we were led from certain symptoms to suspect that suppuration had already taken place in the joint, the original wound being at this time closed. In this suspicion we were probably correct, because although both local and general inflammatory symptoms declined immediately after the application of the ligature in the most decided manner, still, some forty-eight hours subsequently the original wound re-opened and the *thickest* possible pus flowed, or rather oozed up, evidently from within the joint. This thick pus was made up of just enough liquor

puris to make it a soft solid—a condition due, I thought, to the withholding of fluid from the limb by the ligature on the artery.

The two preceding cases will contrast well with the following, in which ligature of the brachial was performed apparently to little purpose only.

Inflamed Hand; Ligature of Brachial Artery.—Case 18 (in table of arteries) was one of acute inflammation of the hand, in a middle-aged female, consequent on a poisoned wound. The whole hand was enormously swollen, with the fingers bent upon the palm. Her temperature was 103°, and the patient was greatly exhausted and had a dry, brown tongue. Just above the wrist was a patch of redness, as though suppuration either had already or was about to set in. I tied the brachial artery in the *middle* of the arm, but it is most essential to notice that the effect upon both local and general symptoms was very slight when compared to the alteration for good, with ligature of the main artery in the *lower* limb. Pus formed above the wrist, but the palm escaped, and the fingers were no longer flexed. The patient died two months later of pyæmia.

In future, should the necessity arise, I would ligature the brachial artery close to the axilla, in order to get above the origin of the *profunda* branches, with the view of still further diminishing the supply of blood to the hand. The arterial anastomoses about the elbow are so numerous, that

although the brachial be tied about its middle, its effect upon the blood supply to the hand will sometimes be too transitory for my purpose as regards inflammation, but highly conservative with respect to the vitality of the part, as the subjoined show.

I tied the brachial for false aneurism in a young man (Case 16*), a good radial pulse existed next day; also in a man aged sixty-six (Case 13,) there was a pulse at the wrist on the third day.

The brachial artery may be tied as follows:—

LIGATURE OF THE BRACHIAL ARTERY.

Anatomical Relations.—This vessel extends, from the termination of the axillary artery, along the inner side of the upper half of the arm, but passing in front towards the lower part of the arm, to end in the middle of the bend of the elbow opposite the neck of the radius. Throughout its extent it is covered in by skin, superficial fascia, and deep fascia, and in the middle of the arm is overlapped by the belly of the biceps muscle. The artery is attended by venæ comites, into one of which the basilic vein—running up to this point superficial to the artery—usually empties itself about the middle of the arm. The median nerve has different relations to the artery in various parts of the arm. Above, it is external to; in the middle, crosses in front or behind; below, it is internal to the vessel.

* See p. 96.

The coraco-brachialis and biceps form a projection along the outer side of the whole course of the artery, and a groove or depression behind and external to these muscles, readily seen and felt on the surface, also marks the position of this vessel. The round cord of the median nerve can usually be felt through the skin, and will serve as a guide to the artery.

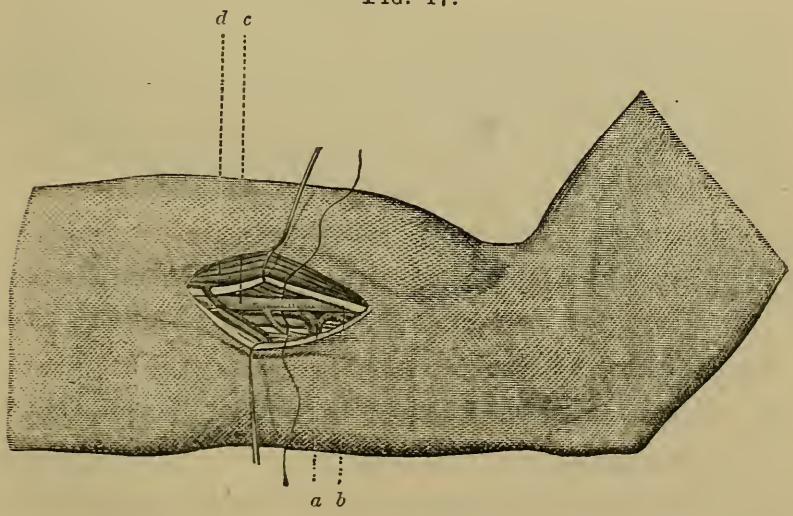
OPERATION.

Ligature in the Middle of the Arm.—From what has been said above, the student will have determined the position of the artery; and since this vessel is superficial throughout, it may be ligatured with comparative ease at any point of its course. An incision from two to three inches in length should be made, for example, in the middle of the arm, dividing only, and with care, the skin, lest the basilic vein be wounded; the superficial fascia and deep fascia should be divided upon a director, just on the inner side of the median nerve, which latter can be readily felt by the finger lying usually in front of the artery, but occasionally behind it. Flex now the fore-arm, separate the edges of the wound, and draw the biceps muscle and median nerve aside; the artery will be found in its sheath, with a vena comes on either side of it. The operator must take care not to make his incision too far back, lest he fall upon the ulnar nerve instead of the median: he would never find the artery behind the ulnar nerve.

When in doubt, observe the direction of the muscular fibres already exposed, and follow the course of the nerve for a short distance to ascertain the direction it is taking; the ulnar nerve, after reaching the middle of the arm, will be found passing downwards and backwards, and should not then be mistaken for the median. I have repeatedly seen the ulnar nerve mistaken for the median, by students performing operations under my superintendence in Paris.

Fig. 17 represents the operation in the middle of the arm. The edges of the wound are held apart, exposing the artery (*c*), the biceps muscle (*d*), venæ

Fig. 17.



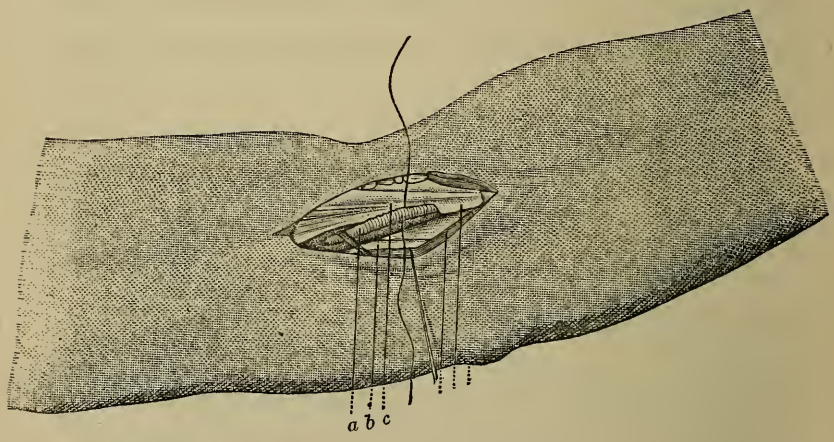
comites (*a*), the median nerve (*b*); the white cord of the ulnar nerve is also seen along the floor of the wound.

Ligature at the Bend of the Elbow.—The brachial

artery may also be readily reached at the bend of the elbow, where it lies on the front of the arm, beneath the aponeurotic expansion from the biceps tendon.

An oblique incision, two and a half inches in length (Fig. 18), should be made over the artery, on the inner side of the tendon of the biceps, which will serve as a guide to the vessel. The large veins of the region should not be unnecessarily divided. The tendinous aponeurosis (*f*) having

Fig. 18.



been slit up, the artery (*a*) will be found attended by venæ comites, and lying between the tendon of the biceps muscle (*c*) on the outside and the median nerve (*b*) on the inside. Prior to the operation the student should manipulate the limb, so as to ascertain the exact position of the biceps tendon, and have the fore-arm extended during the performance of the operation.

The fourth case known to me is that of a male adult who had sustained an incised wound opening the knee-joint, associated with severe venous hæmorrhage. The bleeding was arrested with difficulty, and violent inflammation of the joint followed. I saw the case in consultation with Mr. Reeves on August 3rd, 1870, and advised ligature of the superficial femoral. The man was extremely exhausted and wasted, and for days no hope of saving him by amputation had been, nor could now be, entertained. The discharge was most profuse, both from the joint and thigh; perspirations copious; temperature 103°; pulse 135; and a large patch of redness had lately arisen over the front and inner side of the articulation.

The benefit derived from the ligature in this case was almost ephemeral. The man ultimately died.

I shall now give you some American experience. I have received, through the courtesy of Dr. G. C. Blackman, of Cincinnati, U.S., a *résumé*, published by him in the *Cincinnati Lancet and Observer*, of February, 1868, of the cases of traumatic inflammation treated in that country by ligature of the main artery, and which are well worthy of careful study.

I will condense the information that I have gleaned. Up to this moment no one had hinted in any way that the operation had previously been performed. It was utterly unknown in this country.

It appears probable that the femoral artery was

ligatured for wound of the knee-joint first by Henry U. Onderdonk, M.D., in June, 1813, and that the patient was cured. A similar case was so treated by Dr. David L. Rogers, of New York, and in this instance "the man got well by the twenty-fifth day." Dr. Rogers also refers to a case of compound dislocation of the ankle, in which Dr. Mott tied the femoral artery, but the patient died of tetanus. Dr. R. is of opinion that "the danger of mortification from defect of circulation is less than might be supposed" (and that has long been my opinion). A lad, sixteen years old, was the subject of a most severe and extensive gunshot wound of the arm. The brachial artery was ligatured high up, and although little hope was entertained of saving the arm, to the astonishment of all who saw the case, there was merely sufficient inflammation in the wound to produce healthy suppuration and granulation. He recovered rapidly. Dr. H. F. Campbell, of Georgia, speaking from personal experience of six cases, is also a strong supporter of the principle. Dr. Daniel F. Wright, formerly of Winder Hospital, Richmond, records a case of gunshot wound of the thigh, followed by hæmorrhage, and treated by ligature of the femoral at the apex of Scarpa's triangle. "The injured limb was for some days slightly colder than the other, notwithstanding which, the condition of the wound commenced improving from that day." A second case was one of gunshot wound of the middle finger requiring amputation. Gangrene set in and spread

rapidly; hæmorrhage occurred twice, and then the brachial artery was ligatured in the lower third of the arm. Improvement in the wound commenced at once. A third case is one of gunshot wound of the thigh, followed by spreading gangrene, and repeated hæmorrhage. The femoral artery was tied at the apex of Scarpa's triangle, and "the wound healed more rapidly than any lesion of such extent that I have ever witnessed." Two other cases are recorded by Dr. Wright, but were not immediately under his care. The brachial artery was tied in both instances, "with a result exactly similar to that in the cases already detailed." Dr. Wright remarks: "In the five cases witnessed by myself, and in the six cases reported by Dr. Campbell, we have this uniform result—that immediately from the date of ligation, large tumefaction had been superseded by recovery of the original contour, fetid ichorous discharge by laudable suppuration, and phagedenic gangrene by vigorous granulations, resulting in rapid separation of the eroded tissues . . . In all the instances I have given, though the ligature resulted in curing the gangrene, it was not resorted to for that purpose, but for that of arresting hæmorrhage. In the present state of professional opinion it would be bold surgery, savouring perhaps of rashness, to tie the brachial artery for gangrene of the hand, or the femoral artery for phagedenic erosion in the calf of the leg; though my friend, Dr. Campbell, does not stop short of advocating this very procedure." Also, Dr. D. L. Duvall

remarks, that in a paper published at Richmond by Dr. S. P. Moore, Surgeon-general of the Insurgent States, the author stated that "he had performed operations on patients whose limbs, after being wounded, presented all the indications of rapidly approaching gangrene from inflammation, when, fortunately for the patient, extensive hæmorrhage ensued, which necessitated the ligature of one or more of the large arteries of the limb, and to his great surprise, rapid improvement began, and the patient recovered."

Velpeau, too, appears to have given this method of combating inflammation his consideration, and says, in the American edition of his great work on "Operative Surgery," vol. i. p. 679: "As compression of the arteries moderates and even arrests the circulation in the organs situated underneath (beyond?) it seems, at first sight, to constitute an excellent remedy in congestions, engorgements, and acute inflammations of all kinds. It is therefore somewhat surprising that physicians should, for so many years, have omitted to make use of it, under this point of view. At the present time (1839) the mind appears to take another direction, and compression of the arteries, if we are to believe its partisans, should become the sovereign remedy in convulsions, epilepsy, inflammations of the limbs, &c."

However pathologists and physiologists may explain inflammation; however complex may be the process; whatever share in its production may be

ascribed to the vascular system, to the nervous system, and to the tissues themselves, the seat of it, I presume all will admit that an excess of blood is brought to the part. The experience of practitioners in the healing art has, from time immemorial, taught the value of the withdrawal of blood as a remedy for certain inflammations. Thus we have arteriotomy, venæsection, the use of leeches, &c. But all these methods have this disadvantage in common—they *remove* blood from the system—whilst the obstruction of the main channel only *withholds* it from the inflamed part; and may be likened to dry cupping, by which the blood is diverted into other channels, in great measure, *temporarily*, and thus the inflammation is, as it were, starved.

Lawrence says: "Blood is the material by which the increased action of the part is maintained. In the figurative language, which the obviously increased heat has suggested, one may say that it is the fuel by which the fire is kept up. If one could completely command the supply of blood, the increased action might be effectually controlled or arrested."

In considering the propriety of placing a ligature upon a main artery, with a view to arrest acute traumatic inflammation in the part beyond, various questions must be entertained.

First, The *possible* and *probable* result if the case be treated on general principles hitherto accepted.

Secondly, The effects of the ligature (upon

arteries such as the femoral and brachial), *immediate, intermediate*, and *remote*.

On the other hand, in contemplating, in not a few instances, the effect of acute inflammation, of the knee-joint, for example, subsequent to a wound of the same, the prospect is not at all cheering; and I know of no case in surgical practice of injury to a limb, not requiring immediate amputation, which excites more anxiety in the mind of the surgeon for the welfare of his patient than traumatic inflammation of this joint. Its effects, both local and general, are quickly manifested. Swelling, redness and pain, precursors of suppuration, attack the joint and the limb both above and below, while traumatic fever runs high. After the lapse of a few days pus is formed in and about the joint, and for weeks, while the articulation is being destroyed, suppuration spreads, and burrows up and down the extremity. During this period the patient's powers, both nervous and vascular, are becoming exhausted, by pain and loss of sleep and of appetite, consequent on the progressive destruction of the joint structures, as well as by the more or less profuse suppurative discharges. All this time, too, he has been exposed to the risk of erysipelas and pyæmia; and at length, to escape death from hectic, he submits to amputation with a poor chance of recovery.

Suppuration; Sloughing; Hæmorrhage from Hand.—W. D——, twenty-eight years of age, Case 17, (see table of arteries, p. 170), became the subject of acute

suppuration and sloughing of the soft parts of the hand and fore-arm, and disorganization of the wrist-joint, associated with recurring hæmorrhage. To prevent further bleeding, and to remove structures damaged beyond useful repair, I advised amputation, but the patient declined, and I was obliged to be content with ligature of the brachial artery. He died of pyæmia on the eleventh day.

No sooner had the operation been performed than inflammatory symptoms abated; swelling disappeared; suppuration, which had been profuse, was reduced to a minimum; sloughing ceased, and granulations quickly arose.

I must say I was somewhat surprised at this beneficial result of the ligature, for the parts were so damaged by the previous inflammatory action, added to the injury, that I thought it likely gangrene rather than repair might result.

But it sometimes happens that the result of such an accident to the knee is still more disastrous, the patient dying, after weeks of suffering, in possession of the damaged limb, because no opportunity for amputation, with the hope of a successful result, had presented itself.

Severe Contusion, Suppuration; Sloughing; Hæmorrhage.—H. P—— (Case 9), a male aged forty-seven, was admitted on March 9th, 1867. He had sustained a severe squeeze of the knee. Suppuration up and down the limb, and disorganization of the joint followed, but the man was deemed to be too ill to be

submitted to amputation, and he ultimately died of hæmorrhage.

On the other hand, and under the most favourable circumstances that can be anticipated, the prospect is gloomy. A patient may recover with his joint more or less anchylosed and distorted, and the limb more or less useless in proportion to the degree in which its various component parts have been involved in the inflammatory process.

Peter J——, twenty years of age, was admitted on November 6th, 1873, having received an injury to his left knee ten days before. In about a fortnight after the accident the knee-joint was laid open, and a large quantity of pus came from it. He was in the hospital six months, during which period very many incisions were made here and there to let out the matter, and drainage tubes were used from time to time. For many weeks from three-quarters to a pint of pus were discharged twice daily. He ultimately recovered with anchylosis. You will presently see this patient, but I fear will be able to form a very inadequate idea of his former condition, judging from his present shapely and useful limb. This happy result is due to the great care and attention bestowed for weeks and months upon the case by my house-surgeons, Messrs. Mitcheson and R. Kershaw, and dressers, Messrs. Jones, Treeves, Needham, Snell, and Harvey.

It would be out of place to discuss here the treat-

ment of disorganized joints with a view to prevent displacement of bones and consequent inutility. Suffice it to say that in the instances of the knee (a joint especially liable to luxation) that you will see to-night such unpleasant accident has been prevented; and anchylosis being necessary, the proper angle (a most essential point for the patient's comfort in progression) has been attained.

John P——, twenty-seven years of age, was in the hospital at the same time as the former patient. Incisions about the joint were made, and a drainage tube was used once. The inflammatory action, of a comparatively mild character, was more restricted to the neighbourhood of the joint than in the former case. From time to time a fresh attack of inflammation occurred, and these kept him in the hospital almost as long as the above patient who suffered so severely. Even now, twelve months since he left the hospital (March 18th, 1874), the limb has not recovered itself, while that of his fellow-sufferer is most useful. In this case an excess of synovia was the chief secretion from within the joint, associated with a little suppuration outside the capsule. You will see that the man has a firmly fibrous anchylosed joint; and he is an example of the injurious influence of a constitution spoiled by intemperance upon local injury.

In rare instances, so rare indeed that they can scarcely be allowed to influence our prognosis, the patient escapes with a comparatively sound joint.

A. B——, about eighteen years of age, sustained a blow upon the knee, followed by suppuration within the joint. This was evacuated by an incision on the outer side, and the patient was quickly well.

I especially invite your attention to these three patients to-night, because they were all under care at the same time; under the same roof; under the same surgeon; under the same atmospheric and hygienic conditions: but differed in one grand and all-important feature—in constitution. Each illustrates a stage of the disease which it is important to recognise during its progress, with a view to prognosis. The young woman has recovered, probably without a trace of the result of the injury existing to-day; the young man (of intemperate habits), while showing comparatively slight signs of local mischief, suffered severely in his general health, and even now repair is not complete; but the patient whose limb it seemed to most who saw it impossible to save, and which was twice condemned by my experienced medical friend, Mr. Stilwell, of Epsom, survives. It will be difficult, even for those who saw him at his worst, and almost impossible for any who never saw him, to credit the transformation. The reasons of my withholding operative interference—either ligature of the femoral or amputation—were his cheerful and hopeful disposition, a clean tongue, good nights, and never-failing appetite; but above all, although the cartilages were destroyed early in the progress of

the case, and the articular ends of the bones were exposed, these latter never became involved in the inflammatory process, and he was always free from "starting" pains. This symptom is evidence of disease, which very often leads to operative interference, occasionally to death. On the other hand, we had to combat a most profuse discharge coming from all parts of the limb, and a disorganized knee-joint.

It will be out of place to discuss here, in connection with profuse suppuration, how far a large supply of aliment favours this; but I think it worthy of consideration whether or not we overfeed some patients.

The picture I have drawn, I believe truthfully, of the probable consequences of traumatic suppurative inflammation of the knee-joint, is very discouraging. Can we hope for better things from ligature of the main artery? I think I have proved it.

I will now consider the possible effects, immediate, intermediate, and remote, of ligature of the vessel.

The *possible immediate effect* is gangrene more or less of the limb, varying from the shrivelling of a toe to death of the whole as high as the ligature. But this is scarcely likely to happen, because an excess of blood having been now sent to the part, the collateral circulation may be regarded as already in some measure established.

Suppuration; Sloughing of Foot; Hæmorrhage. —Case 20, 21, a female aged forty-nine, in a very depraved state of health, and the subject of diffuse cellulitis, with extensive sloughing about one foot and ankle, was submitted to ligature of the anterior and posterior tibial arteries of the same side to arrest recurring hæmorrhage, she at the time being too weak for amputation. The acute symptoms subsided at once, and hæmorrhage did not recur. She soon died, and the whole foot and ankle seemed to have lost their vitality; but whether any part of this was due to the ligature it is impossible to say, sloughing having already commenced previous to the operation.

The *possible remote effect* is a permanent weakening of the limb, rendering it less valuable as an organ of progression, and, by lowering its vitality, making it less able to bear changes of temperature, or to resist and repair injury and disease.

I must repeat, as worthy of special notice, that in the case of the child already mentioned,* within a week of the operation, a slough formed on the heel from direct pressure. Knowing how slowly such accidental wounds often heal, I feared that in this instance it would be slower still. I was agreeably surprised to find that my anticipations were not realized. The sore closed quickly.

The *possible intermediate effect* is hæmorrhage at

* See p. 169.

the seat of ligature, either from the proximal or distal side. (The former complication requires a re-opening of the wound and search to be made, under difficult pathological conditions, for the bleeding orifice, that a ligature may be reapplied; or else, if this cannot be accomplished, the trunk of the vessel must be exposed as near as practicable to the bleeding point and a thread be passed around it. The latter accident will probably be combated by a well-applied graduated compress and bandage. This subject was fully discussed and illustrated by cases in my former lecture.)

Besides the above-mentioned possible consequences of ligature of the superficial femoral, we must not neglect to inquire into the influence of the operation upon the process of repair necessary to the restitution of the injured limb to health.

In the Paris Revolution of 1830, Jobert tied the *femoral* artery (I presume the common femoral is meant) with a view to cut off the supply of blood from this region brought by the profunda, for hæmorrhage in a case of gunshot fracture at the neck of the femur. Jobert remarks that the operation acted as a powerful antiphlogistic agent, and that the resulting inflammation and suppuration were much less than generally follow these injuries. The patient recovered.*

Granted that a given supply of arterial blood is necessary to health, and that to repair an injury

* "Plaies d'Armes à Feu," Paris, 1830, p. 262.

more than the usual quantity is requisite, one would expect either that repair would be slower after ligature than without it, or that the disease would degenerate from the acute to the chronic, or perhaps even to the ulcerative or gangrenous. And I am inclined to think that, in the case which was the origin of my operation and these remarks, the wound which opened the joint, as well as a small incision made subsequently over the inner side of the knee to give exit to supposed pus present there, healed more slowly than they would have done had not the vascular supply of the limb been interfered with. If I am correct in this opinion, questions arising out of it are—at what age and state of constitution and at what stage of the disease is this method of treatment admissible? At present I am rather of opinion that the age and state of health of a patient (with special reference to his heart and arteries) who would have the barest prospect of recovery from an uncontrolled suppurative inflammation of the knee-joint would weigh with me against the use of the ligature, and I should try compression, either digital or instrumental. In all probability the injury would be fatal under any circumstances.

The stage of the disease at which ligature of the main vessel (femoral for example) would be contra-indicated, would appear to be, judging from very limited experience, the suppurative, but of long standing.

This observation is supported by the progress of Mr. Reeves' case.* The good effect of the ligature was very transient, a circumstance probably due to the high vascular condition of the part consequent on prolonged inflammation in it.

On the other hand, judging from equally limited experience in the child,† profuse suppuration of a more recent date may be arrested by the ligature.

In the upper extremity in which arterial anastomosis is more free and repair more readily effected, the brachial artery might be ligatured at a more advanced stage of suppuration with every prospect of success. In Cases 12, 15, and 17, instances of inflamed hand associated with extensive suppuration and some sloughing, a favourable change occurred directly after the application of the ligature to the brachial artery.

The *precise* moment and *indication* for the application of the ligature in the lower extremity is when suppuration is only suspected to have occurred, or has only just set in.

When enumerating the risks inherent to the ligature, the possible ill-performance of the operation—a segment or whole of the vein being included in the ligature—ought not to be omitted.‡

Time does not allow me to compare further the result of acute suppurative inflammation treated on

* Page 181. † Page 169.

‡ Maunder's "Operative Surgery," 1873, p. 87:—"I have repeatedly seen the vein wounded by gentlemen attending my 'course of operations' in Paris."

the *ordinary* principles of surgery with the *extraordinary*, or ligature of the main artery. As I have said elsewhere,* I believe the sudden obstruction of a main artery to be very much less dangerous than is generally supposed.

We have been apt to draw our conclusions from instances of known diseased vessels, as in cases of aneurism. I was once present when a friend accidentally wounded the superficial femoral artery while opening an abscess in the thigh. We at once placed a ligature above and below the wound in the vessel, and no ill consequences whatever arose.

On September 7th, 1867 (Case 10), I placed a double ligature upon the superficial femoral artery of a young man, within an hour of its being wounded. He quickly recovered without the least sign of want of circulation in the foot.

Again in 1871 (Case 11), I ligatured the superficial femoral for a contuso-lacerated wound of the vessel. The man was of intemperate habits. Gangrene attacked the wound, and the man died ten days subsequently; but there was never the least evidence of insufficient supply of arterial blood to the foot.

These cases suffice to show how rapidly the collateral circulation is established, and the part does not perish.

Wardrop also says: — "The enlargement of the anastomosing vessels to a certain extent takes place

* "Clin. Soc. Trans.," 1869.

almost instantly after the trunk has been tied. I observed this in a child in whom I had secured the carotid artery. I could see the branches of the temporal and occipital underneath the delicate integument enlarging, and thus actively acquiring great additional vigour immediately after the operation."*

There is thus accumulated a fair amount of experience to show that the principle of *withholding* blood from an inflamed structure, under certain conditions, is immediately beneficial. As to the means to this end, let them be as innocent as may be consistent with success. I would not for a moment insist on the application of a ligature in all cases where the principle is to be tried, provided that a simpler method will suffice, whether by compression with a tourniquet, by acupressure needle, or by hand. But it must not be forgotten that it is one thing to suggest a mode of treatment and another thing to carry it out efficiently. The ligature once applied, all anxiety as regards the passage of blood ceases; but less decided measures above-mentioned require such care and attention to details as can rarely be given. Having witnessed the value of the principle, I do not hesitate to urge upon the profession a trial of it when practicable.

It may appear strange that I have not tied an artery oftener for inflammation; but I did not wish to ride my hobby to death, nor to bring the principle into discredit.

* Wardrop on Aneurism, p. 12.

Facts and *conclusions* :—

That ligature of the superficial femoral artery has arrested acute inflammation consequent on wound of the knee-joint.

That ligature of a main artery will quickly diminish profuse suppuration, and prevent death by exhaustion.

That, while it arrests profuse suppuration, it will, by allowing the patient to gain strength, afford an opportunity for amputation at a future time.

That gangrene and secondary hæmorrhage, as the result of ligature, should not be anticipated in the healthy subject.

That the dread of these has arisen from our knowledge of the consequences of the ligature in instances of known diseased vessels (aneurism for example).

That a slough on the heel, caused by the pressure of a splint, was quickly detached and the wound soon closed, although the superficial femoral had been tied a few days previously.

That the arterial tension of the rest of the body will be increased beneficially by the ligature.

Such, Mr. President, are the conclusions at which I have arrived from a review of the above subject; but seeing that this operation was originated in America long before I was born, while I thought it had been first suggested by me in 1867, I may well say, "There is nothing new under the sun."

I have now come to the end of my "Lettsomian Lectures," and in doing so beg, once more, to thank

the Council of the Medical Society of London for having nominated me to the honourable office, and my audiences for having listened patiently to my discourses.

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THE WIRE COMPRESS.

While these pages are passing through the press an abstract of a paper on "Two Cases of Aneurism, one of the Carotid and one of the Femoral Artery, treated by the Wire Compress," by J. Dix, M.R.C.S. Eng., Hull, has fallen under my notice.*

"The wire compress here spoken of was introduced to the profession by Mr. Dix ten years ago, as a substitute for the ligature. The full details of the method, with illustrated cases, were published in the *Edin. Monthly Journ.* for September, 1864. At that time he had only used it for wounded blood vessels; but he also spoke of its applicability to arteries in their continuity, and explained the process for aneurism. He now related two cases in which it was so used on the carotid and on the femoral artery. Both were successful. In the latter, the incision, five inches long and an inch and a half

* *Brit. Med. Journ.*, August 28th, 1875.

deep, healed by first intention. The operation is as follows:—The artery is cut down upon and the wire is drawn under the artery by the aneurism needle in the usual way. Each end of the wire is then attached to a needle, and so brought out through the tissues by the side of, but clear of the wound, so that the ends are about half an inch from each other. A piece of cork is placed between the points of exit of the wire, and pressed firmly down in the course of the artery; and over this the wire is tightly twisted till the circulation is stopped. In each of the cases related, a feeble current of blood was admitted into the sac for three days, and only on the fourth day was it entirely cut off. In twenty-four hours afterwards, consolidation of the aneurism had taken place."

In Mr. Dix's MS., to which I have had access, the following comparisons are drawn:—

"The Wire Compress	
Does not damage the coats of the artery	As the ligature does.
It is not a foreign body in the wound	As the ligature is.
Therefore it does not excite suppuration and impede healing	As the ligature does.
It is not a fixture upon the artery	As the ligature is.
But can be removed or relaxed at any time	The ligature cannot.
It does not ulcerate through the artery and open the blood-channel	As the ligature does.

Therefore bleeding is impossible	With the ligature there is always the risk, and not seldom the occurrence of bleeding.
It causes a retarded circulation and gradual occlusion, if desired, so diminishing the risk of gangrene	Which cannot be done by the ligature; hence, gangrene often follows its use.
Ultimately, or even at first, if desired, it effects entire obstruction to the current of blood	As effectually and completely as the ligature does.
It affords a wider choice of locality	Than the ligature does.
And is applicable to all arteries alike	Which the ligature is not.
As compared with the Catgut:	
It is not liable to become relaxed or detached too soon .	As the catgut is.
It does not cut the coats of the artery	As the catgut does.
Thus it confers absolute security against hæmorrhage .	Which the catgut does not.
It causes gradual occlusion if wished	Which the catgut cannot do.

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